Assessment And Treatment Of Areas In Ohio Impacted By Abandoned Mines

United States
Department of Agriculture

Soil Conservation Service

United States
Department of
Agriculture

In Cooperation With:

Economic
Research
Service

Forest
Service

Ohio
Department
of
Natural
Resources

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PREFACE

The study "Assessment and Treatment of Areas in Ohio Impacted by Abandoned Mines" was requested by the Ohio Department of Natural Resources specifically to assist the Abandoned Mine Lands (AML) program administered by the Division of Reclamation.

The Division is responsible for carrying out those sections of the Ohio Code which regulate the reclamation of strip mined land. It is charged with insuring compliance under the existing law as well as restoration of abandoned areas affected prior to August 3, 1977.

The Division presently carries out its regulatory functions with fees assessed for mining permits and with returns from a severance tax levied on minerals mined in Ohio. The Ohio legislature has passed legislation which enables the state to take over primacy of PL 95-87 upon approval by the Office of Surface Mining of the state's program submission. The Division acts in cooperation with the Soil Conservation Service in carrying out the Rural Abandoned Mine Program (RAMP). Other sources of funding include the Appalachian Regional Commission, and the U.S. Environmental Protection Agency.

The Secretary of Agriculture designated the Soil Conservation Service (SCS) as chairman of the Field Advisory Committee which provided the coordination of the three responsible USDA agencies. The Forest Service (FS) and the Economic Research Service (ERS) participated under provisions of the memorandum of understanding. This cooperative study has been coordinated with the Ohio Environmental Protection Agency and the local Soil and Water Conservation Districts and local RAMP committees. Approximately twenty (20) public meetings were held throughout the 26 county study area to gain input from local sources on specific mine related problems.

SUMMARY

"Assessment and Treatment of Areas Impacted by Abandoned Mines" is a Cooperative River Basin Study. Cooperating agencies are: the Ohio Department of Natural Resources, Division of Reclamation; the U.S. Department of Agriculture, Economic Research Service, Forest Service, and Soil Conservation Service.

The study area includes a 26 county area in southeast Ohio which contains 30 watersheds which were studied in detail (see "Map of Study Area"). Mine related problems addressed in the study are: (1) erosion, sedimentation, and flooding; (2) loss of useful land; and (3) mine drainage. The study treats in less detail the concerns of dangerous impoundments, visual pollution, landslides, and abandoned equipment. The 30 study watersheds were isolated in previous studies by the Ohio Division of Reclamation as having the most severe mine related problems.

The Field Advisory Committee has decided that for economic evaluation purposes, the conditions in the year 1985 will be considered both "present" and "future".

The results of this study will assist the cooperating agencies in the use of their funds for effective reclamation work in the areas of Ohio where it is most needed.

Erosion rates on abandoned strip-mined land represent by far the highest soil losses on any land within the state of Ohio. Erosion rates in excess of 200 tons per acre per year were measured over a large area of strip mine spoil in Meigs, Athens, and Gallia Counties. Average erosion rates on strip mine spoils in nine of the study watersheds were in excess of 50 tons per acre per year. Erosion rates on one massive gob pile in the Rush Creek Watershed, Perry County, Ohio, were in excess of 1,100 tons per acre per year. Average erosion rates on spoils in all study watersheds, except Little Yellow Creek, were in excess of 5 T/A/YR with most being in excess of 10 T/A/YR.

Sediment deposition in stream channels and adjacent valley flood plains is a significant visible problem which occurs within approximately 60% of the watersheds in the study area. Twenty-three (23) significant depositional areas were measured within the study area. These ranged in size from 10 acres up to 646 acres, and in average thickness from 1 to 6 feet.

Approximately 3,435 acres have been significantly blanketed by strip mine sediment deposition. In some areas, swamping has occurred on what was once productive cropland. In other areas, not as severely impacted, sediment deposition has reduced the capacity of stream channels. This causes an increase in the frequency and severity of flooding. As a result, agricultural flood plains have switched from more intensive cropping patterns to less intensive uses, such as hayland and pasture. Although limited in impact on overall agricultural production in the study area, the effect on individual landowners has been devastating.

Loss of useful land has occurred on 74,428 total acres representing 64,566 acres of strip-mined land and 9,862 acres of bottom land downstream from the mined areas. Almost all of the pre-mining cropland was lost in both areas, grassland in use was reduced 75%, and forest land acreage remained the same. These losses were balanced by tremendous increases in barren land and water pits.

Natural discharge of acidic water existed in Ohio long before the mining of coal began. This acid is formed by natural processes when the mineral pyrite, iron disulfide (FeS_2), is exposed to oxygen and water forming a weak solution of sulfuric acid (H_2SO_4). As the solutions of sulfuric acid pass over and through the rock and soil surrounding the pyrite, the acid water reacts with other minerals to produce soluble sulfates of iron, aluminum, manganese, calcium, magnesium, and sodium.

Pyrite occurs naturally in coal-bearing strata; mining of coal exposes large quantities of pyrite-bearing coal, sandstone, and shale units to water and oxygen, and thus greatly accelerates the natural oxidation processes. This mining results in the significant increase in the production of chemical pollutants (e.g. acidification, metal contamination). These toxic solutions flow over the surface of the strip mines, percolate through mine spoil, or flow outward from underground mines through openings and fractures in rock units to enter surface streams and underground aquifers. Severe off-site water quality problems are the result.

Approximately 4,600 miles of perennial streams flow through the 30 study watersheds. Tabulations of the water quality data revealed nearly 1,400 stream miles have chemical mine drainage pollution and 636 miles exhibit sedimentation (physical pollution).

Landslides, dangerous impoundments, visual pollution, and abandoned equipment problems occur within nearly all study watersheds. Their impacts are very local in nature, usually including health and safety problems, transportation system damage, and asthetic degradation of local environments.

The objectives of the study which were formulated by the Field Advisory Committee are: (1) to evaluate and supplement existing inventories; (2) to survey the most severely impacted areas as indicated in previous studies and inventories; (3) to analyze existing conditions of mined areas and their relationship and/or their resource environmental and economic impact on downstream areas and/or communities; (4) to evaluate and compare proposed alternatives for correction of on and off-site problems technologies and urgency of treatment; (5) to develop a ranking and/or priority of impacted areas which are capable of being corrected using existing technology; (6) to develop cost estimates for needed reclamation in severely impacted areas; (7) to determine the impacts of alternative strategies for treatment; and (8) evaluate the feasibility of remining or other resource recovery activities.

In order to accomplish the study objectives the current AML inventories were updated and supplemented. The Abandoned Mine Lands National Inventory Phase II Problem Area Data Sheets were supplemented and updated in each county. Applicable data was entered into a computer file which had great versatility in possible arrays of data retrieval. Questionnaire data from public meetings in 20 counties throughout the study area also became part of the data base. The 26 county study area was divided into four geologic regions for the purpose of isolating problems and solutions which are related to geologic conditions.

Ten alternative methods for treating abandoned mine problems were studied for their effectiveness in reducing the problems of erosion, sedimentation, flooding, loss of useful land, and water quality. These methods are: resoiling of mine spoil; preparation and seeding of existing mine spoil; chemical application and reseeding; sediment traps; channel work; channel maintenance; mining remaining coal; covering mine with impermeable material; water treatment with lime; and sealing deep mines.

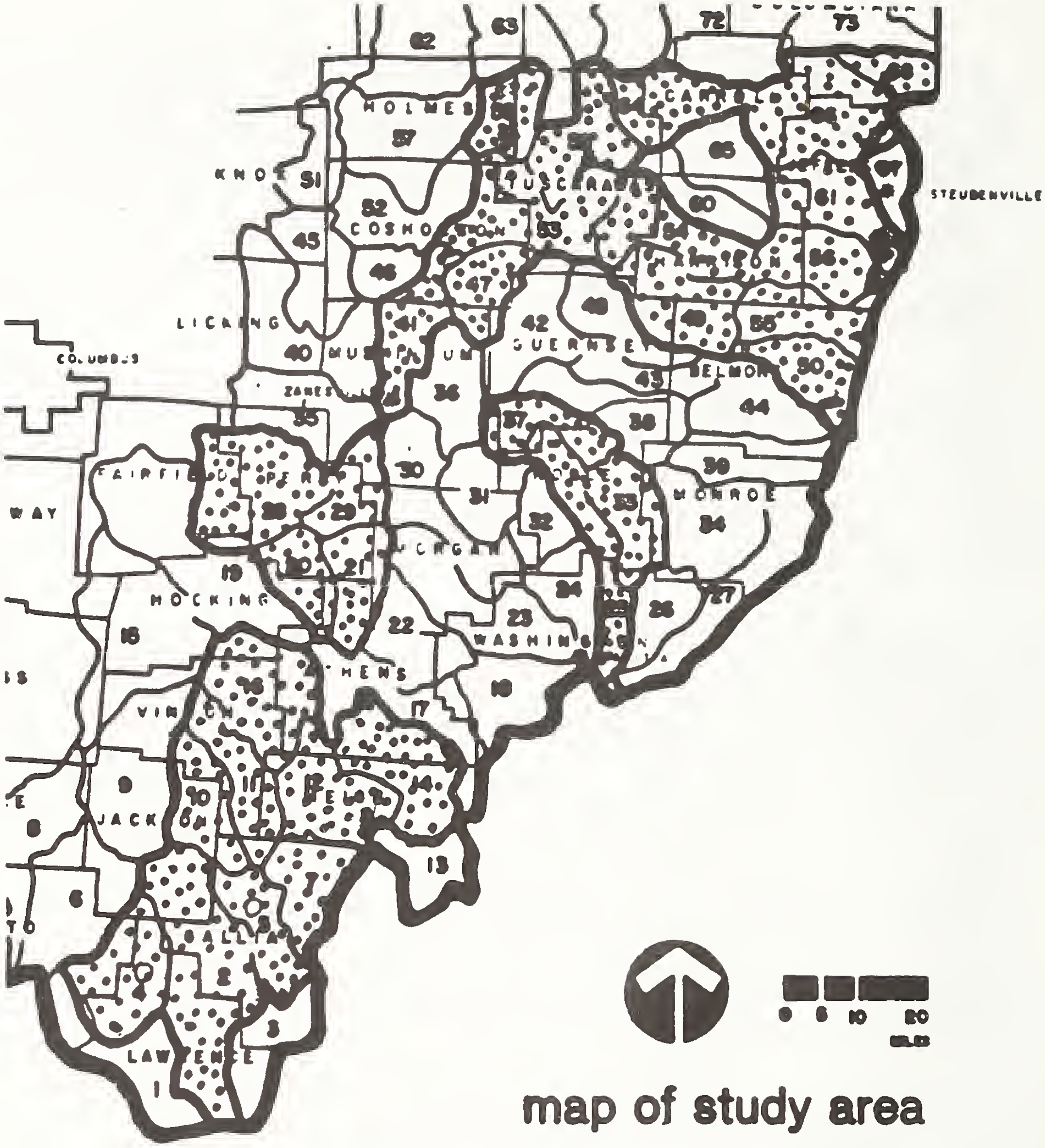
In order to provide a ranking and priority system for the 78 planning units and 30 watersheds, a comprehensive matrix was developed and adapted to a computer system. The matrix was designed to digest input from the massive amount of inventory data generated during Phases I and II of the study. Data input was categorized into four major areas of concern; general, agriculture, environmental, and mining. These categories were further broken down by subject, and then by parameters which were indigenous to their particular subject.

The matrix software was designed to aggregate point totals and provide numerical rankings at the planning unit and watershed levels by area of concern, subject, parameter, and overall. This versatility was built-in to serve decisionmakers who must deal with different mixes of concerns, subjects, and parameters.

The programs and services of the ODNR, Division of Reclamation, the U.S. Soil Conservation Service, and the Office of Surface Mining apply directly to needed reclamation in the 26 county study area.

Alternative plans investigated for the study area include a National Economic Development Plan, and an Environmental Quality Plan.

Appendix 10 has been bound separately and includes site specific maps for all 30 study watersheds. The maps portray the mine related problems identified in the study and should be sufficient for detailed field use. Enlargements of the watershed maps (2X) have been printed in limited quantities.



map of study area

2. Symmes Creek
4. Pine Creek
5. Lower Raccoon
7. Ohio River Trib.
10. Little Raccoon Creek
11. Raccoon Cr. & Elk Fork Raccoon Cr.
12. Leading Creek
14. Shade River
16. Raccon Cr. Headwtrs.
20. Monday Creek
21. Sunday Creek
25. West Fork Duck Cr.
28. Rush Creek
29. Moxahala Creek
33. East & Middle Forks Duck Creek
37. Buffalo Fork - Wills Creek
41. Muskingum Trib.
47. Lower Wills Creek
49. Upper Stillwater Cr.
50. McMahon Creek
53. Tuscarawas Trib.
54. Stillwater Creek
55. Wheeling Creek
56. Short Cr. & Ohio River Trib.
58. Sugar Creek
59. Stone Creek
61. Cross Creek
64. Conotton Creek
66. Yellow Creek
68. Little Yellow Creek

Chapter I - Problems and Concerns

Introduction:

As a result of the past mining and geologic setting of Ohio's coal region, many mining-related problems are present in the region. Those problems which were treated in detail include: (1) erosion, sedimentation, and flooding; (2) loss of useful land; and (3) mine drainage. The study will treat in less detail the concerns of dangerous impoundments, visual pollution, landslides, and abandoned equipment, and open mine shafts.

The Field Advisory Committee has decided that for economic evaluation purposes, the conditions present in the year 1985 will be considered both "present" and "future". Problems and concerns within the mine study area tend to change predominantly as a function of man's input.

The processes of mining, whether it is deep mining or strip mining, taps or uncovers what could be termed as "Nature's Junk Pile". The Pennsylvanian Age cyclothems (alternating cycles of sandstone, coal, underclay, limestone and shale) contain mineral assemblages which are extremely unstable when exposed to the earth's atmosphere. Chemical and biologic reactions occur that cannot be reversed by natural forces. Therefore, any desired changes in the continuously degraded environment must be induced by human effort. Natural improvements may not measureably occur at all within a conceiveable economic time reference.

Reclamation activities in the basin area have already wrought remarkable changes in local mine environments. However, the continuation of reclamation work in orphan mines is, to a great extent, dependent on funding through PL 95-87, the Surface Mining Reclamation and Control Act. This Act is scheduled to expire in 1992. Pressure to reclaim the high priority watersheds before this funding is terminated is very great for the state, federal, and local agencies involved in this study.

A. Erosion

Erosion rates on abandoned strip-mined land represent by far the highest soil losses on any land within the state of Ohio. Erosion rates in excess of 200 tons per acre per year were measured over a large area of strip mine spoil in Meigs, Athens, and Gallia Counties. Average erosion rates on strip mine spoils in nine of the study watersheds were in excess of 50 tons per acre per year. Erosion rates on one massive gob pile in the Rush Creek Watershed, Perry County, Ohio, were in excess of 1,100 tons per acre per year. Average erosion rates on spoils in all study watersheds, except Little Yellow Creek, were in excess of 5 tons per acre per year (5 T/A/YR), with most being in excess of 10 T/A/YR.

In general, those acres which are eroding at a rate of 25 tons per acre or greater annually will never naturally produce a significant vegetative cover of any type. An estimated 36,000 acres are in this category.

Table 1 presents by watershed the matrix ranking, score, and geologic region for the combined "total erosion" and "erosion rate" areas of concern (see Planning Unit Evaluation Matrix, Chap. II, E, 1).

The worst erosion problems occur in Regions 3 and 4, as defined by the Ohio Division of Reclamation. Region 3 consists predominantly of sandstone, shale, and coal of the Pottsville, Allegheny and Conemaugh groups, Pennsylvanian System. Region 4 consists of an eastward extension of strata of the Pottsville and Allegheny groups, Pennsylvanian System. (See Figure 1)

The nine (9) top ranked watersheds having average mine spoil erosion rates greater than 50 T/A/YR were in Regions 3 and 4 (See Figure 1).

Approximately 70% of the watersheds with mine spoils eroding between 25 and 50 T/A/YR were also in these two regions.

These massive erosion problems are the combined result of the following physical and chemical factors which all operate in harmony.

Mine Spoil Chemistry

Aerobic bacterial digestion of pyrites in typical mine spoils creates a by-product of sulphuric acid which prevents or retards plant growth and virtually consumes organic detritus. Most problems with acid spoils occur in Regions 3 and 4. In Regions 1 and 2 the acid spoils are typically buffered by minor limestones which exist below the coal bearing strata and become incorporated in the mine spoil.

Acid mine spoils also exhibit very high chemical and physical dispersion which causes affected soils to slough (melt) almost like sugar in the presence of water.

Physical Properties

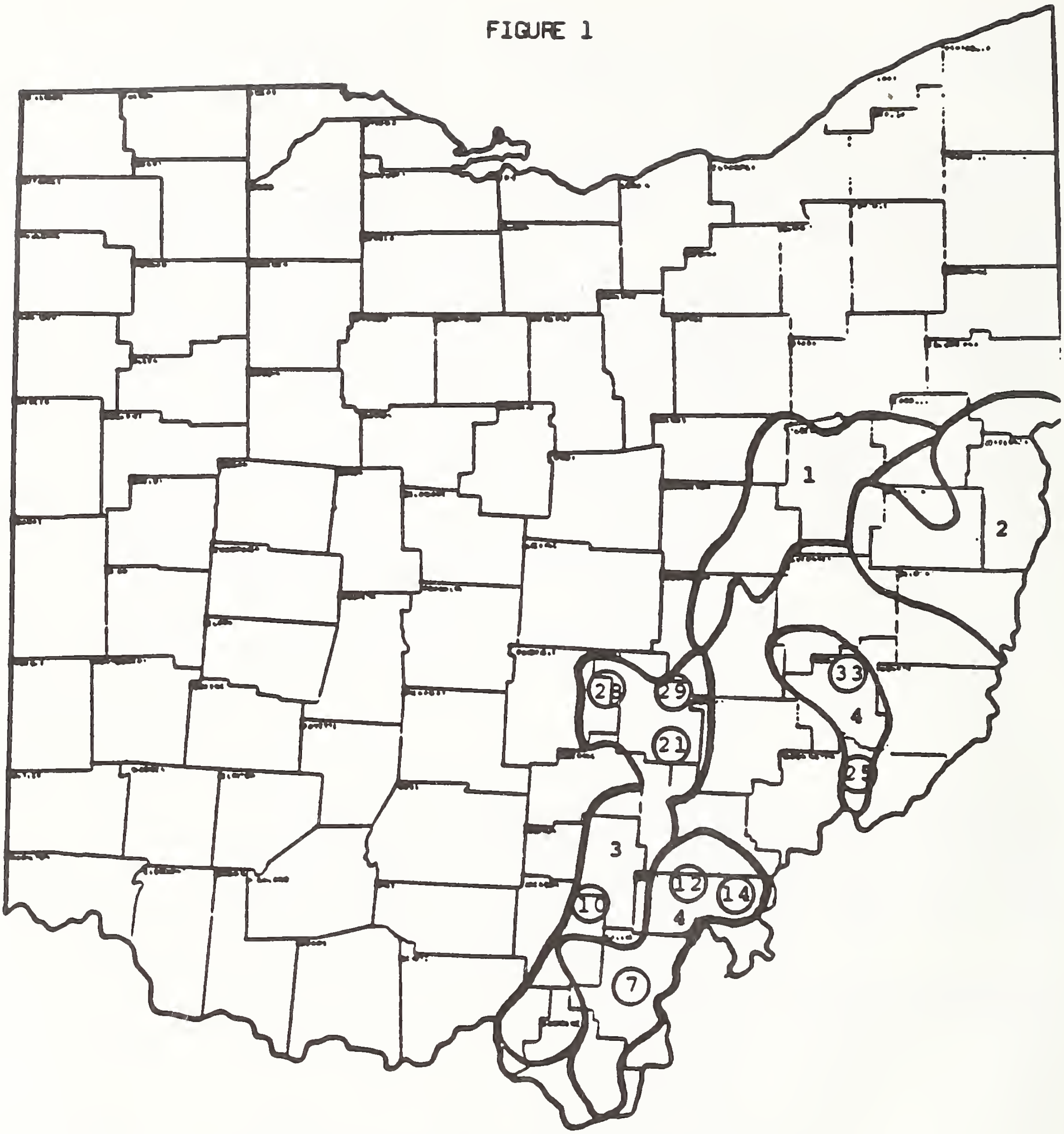
Mine spoils typically exhibit very low shear strengths. Studies strongly indicate that the shear strength of mine spoils is a major controlling factor in their erosional development. Gullies and rills developed in low shear strength mine spoil tend to have a greater width to depth ratio than gullies developed in spoils with a higher shear strength. As running water etches deeper into low shear strength spoils, the sideslopes of the gully or rill collapse into the void at a more rapid rate than do higher strength spoils. This action delivers respectively a greater mass of material to the upland delivery system.

TABLE 1

Total Erosion and Erosion Rate
Combined Ranking by Watershed

Rank	Watershed	Watershed Name	Geologic Region	Total Matrix Score
1	33	East & Middle Fork Duck Creek	4	84
2	12	Leading Creek	4	84
3	7	Ohio River Trib.	4	72
4	10	Little Raccoon Cr.	3	60
5	29	Moxahala Creek	3	54
6	25	West Fork Duck Cr.	4	54
7	21	Sunday Creek	3	54
8	28	Rush Creek	3	36
9	14	Shade River	4	36
10	53	Tuscarawas Trib.	1	30
11	5	Lower Raccoon	4	24
12	4	Pine Creek	3	24
13	64	Conotton Creek	1	24
14	49	Upper Stillwater Cr.	2	18
15	59	Stone Creek	1	18
16	50	McMahon Creek	2	18
17	58	Sugar Creek	1	18
18	47	Lower Wills Creek	1	18
19	2	Symmes Creek	4	12
20	16	Raccoon Cr. Headwtrs	3	12
21	20	Monday Creek	3	6
22	56	Short Cr. & Ohio River Trib.	2	6
23	11	Raccoon Cr. & Elk Fork Raccoon Cr.	3	6
24	37	Buffalo Fork - Wills Creek	3	6
25	41	Muskingum Trib.	1	6
26	55	Wheeling Creek	2	6
27	61	Cross Creek	2	0
28	54	Stillwater Creek	2	0
29	66	Yellow Creek	2	0
30	68	Little Yellow Creek	2	0

FIGURE 1



REGIONAL DISTRIBUTION OF STUDY WATERSHEDS
HIGHEST RANKINGS FOR EROSION AND SOIL LOSS PROBLEMS

REGION 1
No Ranking Basins
Pottsville and Allegheny Groups

REGION 2
No Ranking Basins
Conemaugh and Monongahela Groups

REGION 3
Basins 10, 21, 28, 29
Pottsville, Allegheny, and Conemaugh Groups

REGION 4
Basins 7, 12, 14, 25, 33
Pottsville, Allegheny, and Conemaugh Groups

A portion of the sample of measured gullies in the Shade River and Leading Creek Watersheds exhibited sideslopes with typical angles of repose of 8:1 (horizontal to vertical ratios). Gross erosion rates ranged from approximately 200 tons per acre to 300 tons per acre per year. Where the angle of repose of gully sideslopes was 5:1 or less the gross erosion rates (all sources) were typically less than 100 tons per acre per year.

Physical Relief

Strip mining in the stream dissected Appalachian Plateau occurs predominantly on hillsides. Mine spoils are generally elevated 50 feet to over 300 feet above the local stream base level. Gully gradients through the outslope mine spoils are typically 20% or greater with sections as high as 70%. Water runoff velocities are rapid and turbulent. Undercutting of steep sideslopes causes rapid mass wasting as blocks of mine spoil shear off or slide into gullies. This process often continues unchecked into undisturbed strata beneath the mine spoils.

Deep mining has produced eroding gob piles since the early 1800's. Most gob production occurred in the early 1900's when deep mine production equalled today's total production of coal by all methods. Strip mining was initiated in the late 1940's and has increased ever since while deep mining has decreased. Currently, the majority of coal companies reclaim their operations according to State specifications. However, since 1977, over 42 bonded permits representing approximately 1,000 acres have gone to forfeiture and will require approximately $3,000,000 to reclaim.

Approximately 100 questionnaires were returned from public meetings held in approximately 20 counties throughout the study area. These documents contained information provided by local people concerning their perception of the erosion problems at sites which were familiar to them. This information was utilized in this study and was provided to the Ohio Division of Reclamation for action and for addition to their files. A sample questionnaire has been included as Appendix 9.

B. Sedimentation

Sediment deposition in stream channels and adjacent valley flood plains is a significant visible problem within approximately 60% of the watersheds in the study area. Twenty-three (23) significant depositional areas were measured within the study area. These ranged in size from 10 acres to 646 acres, and in average thickness from 1 to 6 feet.

Approximately 3,435 acres have been significantly blanketed by strip mine sediment deposition. In some areas, swamping has occurred on what was once productive cropland. In other areas, not as severely impacted, sediment deposition has reduced the capacity of stream channels. This causes an increase in the frequency and severity of flooding. As a result, agricultural flood plains have switched from more intensive cropping patterns to less intensive uses, such as hayland and pasture. Although limited in impact on overall agricultural production in the study area, the effect on individual landowners has been severe.

In the Leading Creek and Shade River Watersheds, the deposited sediment is essentially sterile due to its acidity. These sediments support occasional clusters of cattails with roughly 70% of the area being totally barren. Upper Rush Creek and Moxahala Creek Watersheds contain depositional areas which are nearly sterile. In contrast, depositional areas in the Duck Creek Watersheds support pasture operations. The majority of areas studied typically support a mixture of cattails, willows, alders, and poor quality grasses. The sediment problem is also discussed in the "Loss of Useful Land" section of this chapter.

Sedimentation adversely affects water quality, primarily through the presence of acid, and secondarily by the presence of the mineral sediments themselves. Most stream systems which are associated with significant areas of deposition are either totally sterile or are marginal for the support of aquatic flora and fauna. The sediment problem is also discussed in this chapter under "Water Quality Problems".

Sediments which are not trapped near the erosional sources are transported predominantly into the Ohio River, where they must be continuously removed by dredging. Portions of six (6) study watersheds, Sugar Creek, Upper Stillwater Creek, Stillwater Creek, Lower Wills Creek, and Conotton Creek, discharge into major flood control lakes controlled by the Muskingum Conservancy District.

Table 2 presents by watershed the matrix ranking, score, and geologic region for the combined "sediment damage" and "acreage of deposition" areas of concern (see Planning Unit Evaluation Matrix, Chap. II, E, 1).

The most severe sediment problems occur in regions 3 and 4 (See Table 2). Eight of the nine watersheds indicated in Figure 1 as having the most severe erosion problems are also ranked as having the most serious sedimentation problems. All but three of the fourteen watersheds with significant depositional areas are located in regions 3 and 4.

The basic cause of the sedimentation problem is the massive erosion of strip mine spoil and deep mine gob piles discussed under "Erosion" in this chapter. The delivery system is also a fundamental part of the problem. The delivery system in nearly every case begins at or near the top of the mine spoil or gob pile as a rill and continues through a gully system to a local base level stream. Highwall pits and minor depressional areas around highwall pits are usually the only traps in the mined area. These, however, are often in the process of being captured by the headward erosion of gullies. The next sediment trap downstream in the system is usually a natural flat section in the lower valley area which may have a constriction at its lower end.

TABLE 2

Sediment Damage and Acreage of Deposition
Combined Ranking by Watershed

Rank	Watershed	Watershed Name	1/ PU's	Geologic Region	Total Matrix Score
1	12	Leading Creek	3	4	90
2	49	Upper Stillwater Cr.	4	2	78
3	7	Ohio River Trib.	2	4	72
4	33	East & Middle Forks Duck Creek	3	4	72
5	25	West Fork Duck Cr.	2	4	66
6	29	Moxahala Creek	2	3	54
7	10	Little Raccoon Cr.	3	3	48
8	14	Shade River	1	4	36
9	5	Lower Raccoon	1	4	30
10	28	Rush Creek	1	3	30
11	64	Conotton Creek	2	1	30
12	21	Sunday Creek	3	3	24
13	53	Tuscarawas Trib.	3	1	18
14	16	Raccoon Cr. Headwtrs	2	3	18
15	37	Buffalo Fork - Wills Creek	1	4	0
16	55	Wheeling Creek	5	2	0
17	56	Short Cr. & Ohio River Trib.	6	2	0
18	41	Muskingum Trib.	2	1	0
19	58	Sugar Creek	2	1	0
20	20	Monday Creek	3	3	0
21	59	Stone Creek	3	1	0
22	11	Raccoon Cr. & Elk Fork Raccoon Cr.	2	3	0
23	61	Cross Creek	2	2	0
24	2	Symmes Creek	5	4	0
25	4	Pine Creek	2	3	0
26	50	McMahon Creek	3	2	0
27	47	Lower Wills Creek	3	1	0
28	54	Stillwater Creek	1	2	0
29	66	Yellow Creek	5	2	0
30	68	Little Yellow Creek	1	2	0

1/ Planning Units

Major depositional areas also predominate above road fills which cross the lower valley area. The associated culvert becomes clogged with sediment first, restricting flows. Then sediment laden water backs up in the valley, often encroaching on the road itself. These problems become especially severe when several source tributaries merge behind a roadfill or other valley restriction. The sediment source area is typically less than one mile away from the major depositional areas.

Major sedimentatation problems in strip mined areas began in the 1950's with the advent of this mining technique. Valley accumulations reached nearly their present areal extent by the mid-1970's. Currently the depositional areas are aggrading in the vertical direction within their confining valleys.

C. Flooding

An increase in the frequency, depth, and areal extent of flooding in the study area can be attributed to strip mining activities. The high erosion rates on strip mined land has, in some cases, caused significant sediment deposition in downstream channels and floodplains. The deposition reduces the conveyance of the stream and floodplain cross section. Higher flood stages have increased the frequency and depth of flooding on agricultural lands, roads and urban areas. Flooding of highways and bridges has become a serious problem in areas where flood damages were rarely encountered prior to mining activities. In some cases swamping has occurred on what was once productive cropland. Agricultural land use has become less intensive in most areas of the flood plain as a result of the increased flooding.

To evaluate the relative magnitude of the increased flooding in the study area, the following five watersheds were selected as being representative of the respective regions:

Region	Watershed No.	Name
1	58	Sugar Creek
2	55	Wheeling Creek
3	28	Rush Creek
4	33	Middle Fork Duck Creek
4	7	Kyger Creek

A detailed analysis of the flooding in the impacted area of these watersheds was made to establish the present condition (post-mining). This was done from field cross sections of the channel and flood plain, and on-site determinations of roughness coefficients, soils, and land use. Standard SCS computer programs were then used to model the hydrology and hydraulics of the watershed and flood plains.

Pre-mining cross sections of the stream and flood plain were determined by measuring the depth of mine sediments along surveyed cross sections. The sections were then altered to reflect the configuration of the stream and flood plain prior to mining. Land use changes in the watershed and the resulting impact upon flooding was also assessed.

This comparison is summarized in the following two tables.

TABLE 3: Increase in Flood Area for Sample Watersheds

Region	Watershed Number	Name	% Increase in Flood Area 2 YR.	10 YR.	50 YR.	100 YR.
1	58	Sugar Creek	7.5	0.3	0	0
2	55	Wheeling Creek	0	0	0	0
3	28	Rush Creek	62.3	45.5	40.3	40.3
4	33	Middle Fork Duck Creek	36.5	26.6	19.7	18.9
4	7	Kyger Creek	2.8	7.9	7.2	7.2

TABLE 4: Increase in Flood Stages for Sample Watershed

Region	Watershed Number	Name	Average Increase in Flood Stage (ft.) 2 YR.	10 YR.	50 YR.	100 YR.
1	58	Sugar Creek	0.4	0.1	0	0
2	55	Wheeling Creek	0	0	0	0
3	28	Rush Creek	2.4	2.1	1.8	1.9
4	33	Middle Fork Duck Creek	3.0	2.9	2.8	2.8
4	7	Kyger Creek	1.2	1.2	1.2	1.2

D. Loss of Useful Land

The study concentrated on the most severely impacted areas in the 30 drainage basins. The impacted areas included the mined land and the downstream land impacted by the mining.

A change from cropland, grassland and/or forest land to either barren land, wetland, pits or developed land constituted the loss of useful land for the purpose of this study.

These impacted areas (problem areas) represent 74,428 total acres. There were 64,566 acres of mined land and 9,862 acres of affected land downstream. (See Tables 5 and 6).

Land use and cover in the mined areas were determined prior to mining and after mining (1985). Significant changes were as follows: (1) almost all of the cropland was lost; (2) forest land acreage remained the same; (3) grassland in-use was reduced 75%; (4) developed land acreage remained the same; and (5) the amount of perennially barren land and water pits increased enormously.

TABLE 5

Land Use Change in Upstream Mined Area

		Total	Cropland			Grassland						
		Acres	Total	In Use	Idle	Total	In Use	Idle	Forest	Barren	Pits	Developed
Region 1	Prior	7,198	1,366	1,366	0	2,611	2,480	131	3,184	0	0	37
	1985	7,198	5	5	0	273	87	186	5,169	1,632	63	56
	Change	0	-1,361	-1,361	0	-2,338	-2,393	+55	+1,985	+1,632	+63	+19
Region 2	Prior	9,128	3,231	3,007	224	3,488	3,148	340	2,108	0	0	301
	1985	9,128	437	427	10	3,925	1,873	2,052	3,003	1,169	448	146
	Change	0	-2,794	-2,580	-214	+437	-1,275	+1,712	+895	+1,169	+448	-155
Region 3	Prior	25,427	3,026	2,996	30	8,100	7,142	958	14,018	38	0	245
	1985	25,427	20	20	0	1,483	1,123	360	16,281	6,377	857	409
	Change	0	-3,006	-2,976	-30	-6,617	-6,019	-598	+2,263	+6,339	+857	+164
Region 4	Prior	22,813	2,668	2,503	165	8,869	8,471	398	11,177	40	0	59
	1985	22,813	0	0	0	4,314	2,160	2,154	6,521	11,572	364	42
	Change	0	-2,668	-2,503	-165	-4,555	-6,311	+1,756	-4,656	+11,532	+364	-17
Grand Total Study Area	Prior	64,566	10,291	9,872	419	23,068	21,241	1,827	30,487	78	0	642
	1985	64,566	462	452	10	9,995	5,243	4,752	30,974	20,750	1,732	653
	Change	0	-9,829	-9,420	-409	-13,073	-15,998	+2,925	+487	+20,672	+1,732	+11

TABLE 6

Land Use Change in Downstream Impact Area

		Total	Cropland			Grassland						
		Acres	Total	In Use	Idle	Total	In Use	Idle	Forest	Barren	Swamp	Developed
Region 1	Prior	83	73	73	0	10	10	0	0	0	0	0
	1985	83	35	28	7	0	0	0	0	18	30	0
	Change	0	-38	-45	+7	-10	-10	0	0	+18	+30	0
Region 2	Prior	2,961	1,025	1,004	21	1,291	1,206	85	349	0	48	248
	1985	2,961	851	779	72	501	389	112	729	20	494	366
	Change	0	-174	-225	+51	-790	-817	+27	+380	+20	+446	-118
Region 3	Prior	1,289	373	373	0	632	632	0	243	1	0	40
	1985	1,289	32	32	0	212	99	113	513	60	388	84
	Change	0	-341	-341	0	+420	-533	+113	270	+59	+388	+44
Region 4	Prior	5,529	2,097	2,097	0	2,524	2,465	59	639	3	106	160
	1985	5,529	682	682	0	1,861	1,613	248	1,352	72	1,316	246
	Change	0	-1,415	-1,415	0	-663	-852	+189	713	+69	+1,210	+86
Grand Total Study Area	Prior	9,862	3,568	3,547	21	4,457	4,313	144	1,231	4	154	448
	1985	9,862	1,600	1,521	79	2,547	2,101	473	2,594	170	2,228	696
	Change	0	-1,968	-2,026	+58	-1,883	-2,212	+329	+1,363	+166	+2,074	+248

Table 7 shows the watershed ranking for the "Loss of Useful Land" category. Distribution of problems is basically random with the exception of the top 10 rankings which are dominated by regions 3 and 4. Watersheds with three to six planning units dominate the top 10 rankings.

E. Mine Drainage - Water Quality Problems

Introduction

Natural discharge of acidic water existed in Ohio long before the mining of coal began. This acid is formed by natural processes when the mineral pyrite, iron disulfide (FeS_2), is exposed to oxygen and water forming a weak solution of sulfuric acid (H_2SO_4). As the solutions of sulfuric acid pass over and through the rock and soil surrounding the pyrite, the acid water reacts with other minerals to produce soluble sulfates of iron, aluminum, manganese, calcium, magnesium, and sodium.

Pyrite occurs naturally in coal-bearing strata; and because mining of coal exposes large quantities of pyrite-bearing coal, sandstone, and shale units to water and oxygen and thus greatly accelerates the natural oxidation processes. This mining results in the significant increase in the production of chemical pollutants (e.g. acidification, metal contamination). These toxic solutions flow over the surface of the strip mines, percolate through mine spoil, or flow outward from underground mines through openings and fractures in rock units to enter surface streams and underground aquifers.

Purpose

The purpose of the water quality reconnaissance phase of this study was to compile data that would indicate the severity and extent of mine drainage in the 30 highest-priority drainage basins in Ohio. This data will allow specific abandoned mine sites to be isolated as sources of the mine drainage pollution.

Methods

The first step in the water reconnaissance phase was to identify areas that exhibited adverse impacts from past mining. A review of United States Geological Survey (USGS) water quality information identified streams in the 30 drainage basins with significant mining-related contamination. In addition, examination of USGS 7.5 minute topographic maps showing the extents of surface and underground mine established further areas to be tested.

TABLE 7

Watershed Ranking
Loss of Useful Land

Rank	Watershed	Watershed Name	1/ PU's	Geologic Region	Total
1	33	East & Middle Forks Duck Creek	3	4	18
2	56	Short Cr. & Ohio River Trib.	6	2	16
3	12	Leading Creek	3	4	16
4	2	Symmes Creek	5	4	14
5	10	Little Raccoon Cr.	3	3	14
6	7	Ohio River Trib.	2	4	12
7	55	Wheeling Creek	5	2	10
8	59	Stone Creek	3	1	10
9	20	Monday Creek	3	3	10
10	21	Sunday Creek	3	3	8
11	50	McMahon Creek	3	2	8
12	4	Pine Creek	2	3	8
13	53	Tuscarawas Trib.	3	1	8
14	29	Moxahala Creek	2	3	8
15	25	West Fork Duck Cr.	2	4	8
16	58	Sugar Creek	2	1	6
17	16	Raccoon Cr. Headwtrs	2	3	6
18	66	Yellow Creek	5	2	6
19	14	Shade River	1	4	6
20	28	Rush Creek	1	3	6
21	64	Conotton Creek	2	1	6
22	11	Raccoon Cr. & Elk Fork Raccoon Cr.	2	3	4
23	41	Muskingum Trib.	2	1	4
24	37	Buffalo Fork - Wills Creek	1	4	4
25	61	Cross Creek	2	2	4
26	5	Lower Raccoon	1	4	4
27	49	Upper Stillwater Cr.	4	2	2
28	54	Stillwater Creek	1	2	2
29	47	Lower Wills Creek	3	1	2
30	68	Little Yellow Creek	1	2	2

1/ Planning Units

A variable number of water samples were taken in each basin depending on the number of identified abandoned mines potentially contributing chemical and/or physical (e.g. sedimentation) pollutants to the streams. One-time water samples were collected during late spring and summer of 1983; however, supplemental sampling occurred in the fall and winter of that year.

On-site measurements of specific conductance and pH were taken using Hach pH kits and Beckman specific conductance meters. Two samples were collected at each station (100ml acidified and 250ml non-acidified), refrigerated, and sent to Analytic & Biological Laboratories of Garden City, Michigan for analysis. The laboratory analyzed each water sample for pH, acidity (as H^+), alkalinity (as HCO_3^-), specific conductivity, suspended solids, sulfate, total hardness, iron, and manganese.

Study Restrictions

Water sampling stations were selected under time restraints and limited resources. Limited available information on the full extent of past mining in the drainage basins restricted the investigation to documented mining locations. Time was not available for a close detailed examination of the drainage basins; and sampling was limited to one-time "grab" samples. In addition, varying weather conditions during the sampling season provided little opportunity to distinguish between high and low flow samples.

Results

Water quality data were assessed on two levels: (1) Qualitatively: to determine the severity of mine drainage pollution in each drainage basin; and (2) Quantitatively: to compute the miles of stream affected by mine drainage in each basin.

The severity of chemical mine drainage pollution was determined by evaluating levels of pH, iron, manganese, sulfate, and specific conductance. The classification of mine drainage impacts from the "Inactive and Abandoned Underground Mines - Water Pollution and Protection Control" report produced by the U.S. Environmental Protection Agency in 1975. Table 8 was used in evaluating the results. Eight-hundred-twenty-nine (829) water samples were analyzed from the 30 drainage basins. The severity of chemical and physical mine drainage pollution is presented in Figures 2 and 3.

Computations for quantitative mine drainage pollution were made using the results from the qualitative analysis. Approximately 4,600 miles of streams flow through the 30 drainage basins. Tabulations of the water quality data revealed nearly 1,400 stream miles have chemical mine drainage pollution and 636 miles exhibit sedimentation (physical pollution). Total stream lengths and chemically/physically polluted stream lengths are summarized in Tables 9 and 10 and Figure 4.

TABLE 8

CHEMICAL AND PHYSICAL MINE DRAINAGE PARAMETERS

PARAMETER	NO DETECTABLE MINE DRAINAGE IMPACT	MINIMAL MINE DRAINAGE IMPACT	MODERATE MINE DRAINAGE IMPACT	SEVERE MINE DRAINAGE IMPACT
Chemical Pollution				
pH (S.U.)	6.5 - 9.0	5.5 - 6.4	4.5 - 5.4	0.0 - 4.5
Total Fe (mg/l)	0.0 - 1.0	1.1 - 5.0	5.1 - 10.0	above 10.0
Total Mn (mg/l)	0.0 - 0.05	0.06 - 2.0	2.1 - 4.0	above 4.1
Sulfate (mg/l)	≤ 250	251 - 600	601 - 960	above 961
Specific Conductance (umhos/cm)	0.0 - 685	686 - 900	901 - 1200	above 1200
Physical Pollution				
Sedimentation (% total stream mileage)	≤ 1.0	1.1 - 12.5	12.6 - 33.0	above 33.0

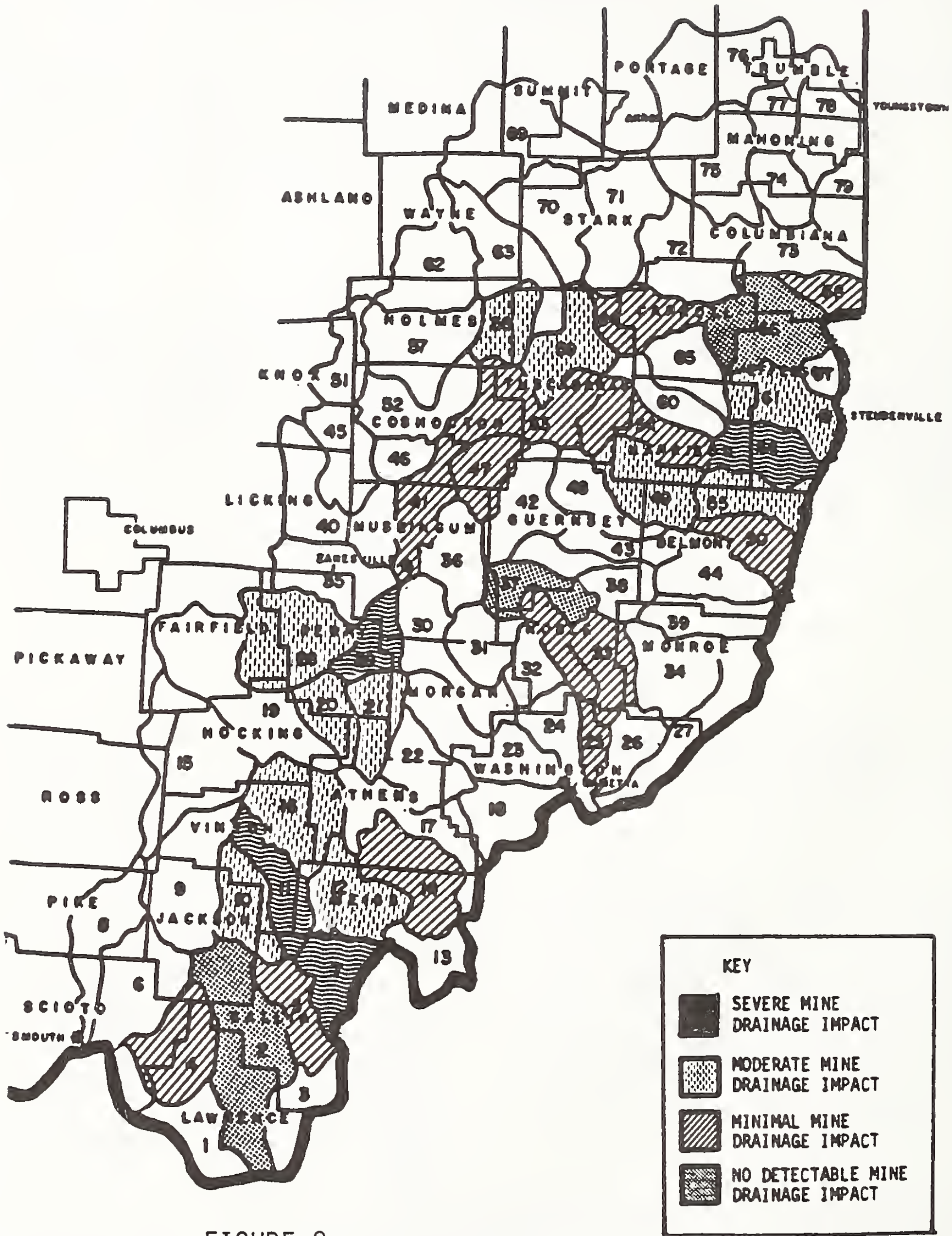


FIGURE 2
CHEMICAL MINE DRAINAGE POLLUTION

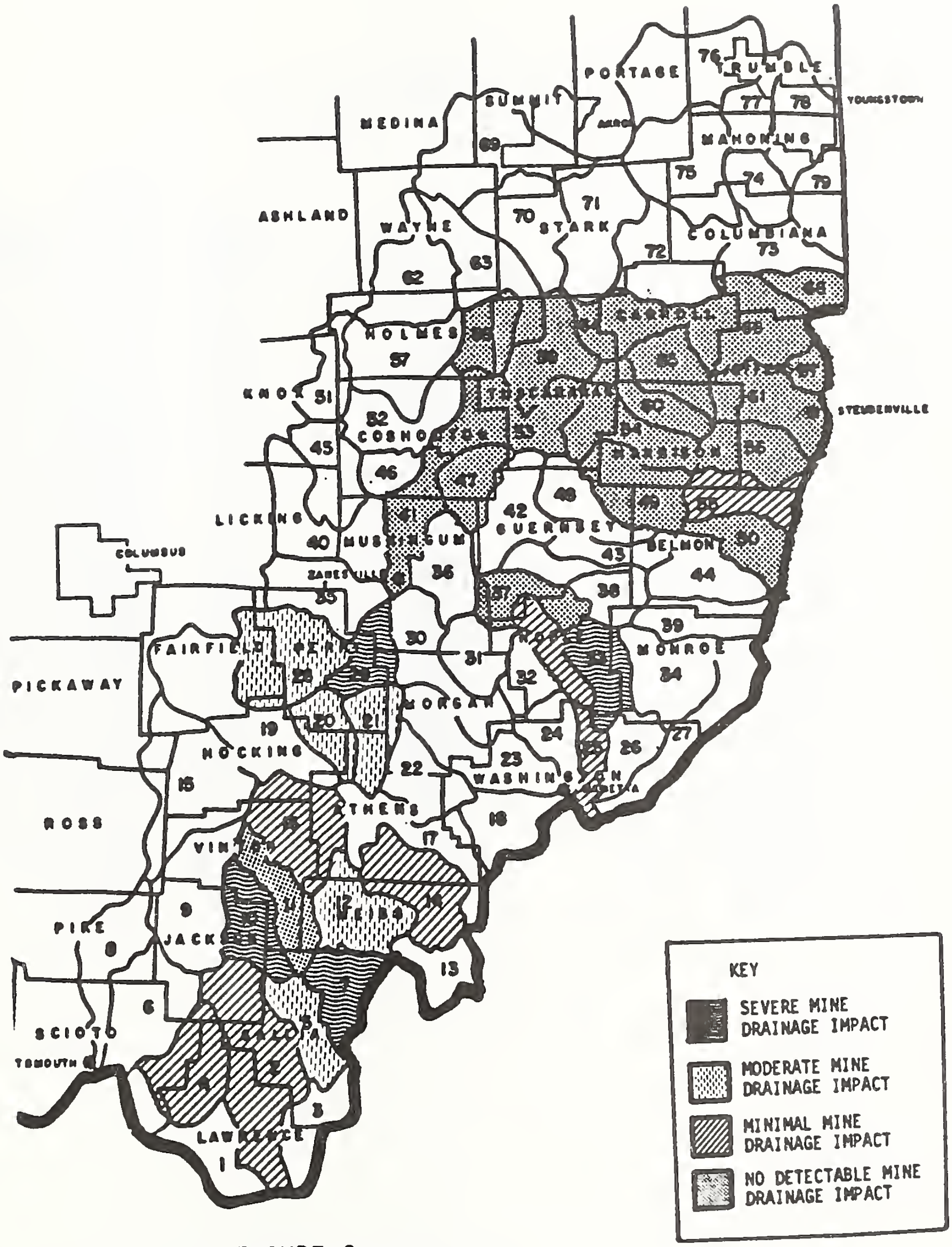


FIGURE 3
PHYSICAL MINE DRAINAGE POLLUTION

TABLE 9

MINE DRAINAGE POLLUTION: CHEMICAL IMPACT

DRAIN. BASIN NUMBER	DRAINAGE BASIN NAME	PLANNING UNITS	TOTAL STREAM LENGTH (MILES)	CHEMICALLY POLLUTED STREAM LENGTH (MILES)	PERCENT CHEMICAL POLLUTION
56	Short Creek	146,148,149,150,151,152	268.49	149.12	55.54
55	Wheeling Creek	142,143,144,145	254.44	123.85	48.68
20	Monday Creek	052,053,054	269.72	117.71	43.64
29	Moxahala Creek	073,074	166.16	100.44	60.45
61	Cross Creek	215,216	143.73	95.53	66.46
49	Upper Stillwater	156,193,194,195	181.80	87.77	48.23
16	Raccoon Headwaters	020,021	155.74	79.77	51.22
59	Stone Creek	168,169,173	145.65	63.74	43.76
7	Ohio River Tributaries	043,044	126.38	58.51	46.30
12	Leading Creek	032,033,034	229.16	57.46	25.07
10	Little Raccoon Creek	018,024,025	113.68	50.67	44.57
14	Shade River	035	142.55	48.01	33.68
11	Raccoon and Elk Fork	016,017	90.69	46.37	51.13
33	East and Middle Fork Duck Creek	107,108,118	203.66	42.69	20.96
5	Lower Raccoon Creek	014	84.86	36.61	43.14
58	Sugar Creek	167,175	136.46	29.84	21.87
21	Sunday Creek	048,050,051	72.68	28.42	39.10
64	Conotton Creek	170,172	165.91	24.81	14.95
50	McMahon Creek	137,138,139	219.89	23.96	10.90
25	West Fork Duck Creek	114,119	178.50	23.79	13.33
53	Tuscarawas Tributaries	164,165,166	213.82	23.40	10.94
4	Pine Creek	003,004	116.77	22.54	19.30
41	Muskingum River Tributaries	081,082	110.98	16.32	14.71
28	Rush Creek	059	94.60	14.68	15.51
66	Yellow Creek	198,199,200,201,202	195.83	11.75	6.00
47	Lower Wills Creek	126,127,128	91.88	6.54	7.12
68	Little Yellow Creek	203	30.97	4.26	13.76
54	Stillwater Creek	162	40.34	0	-
2	Symmes Creek	007,008,009,010,011	289.00	0	-
37	Wills Creek	132	54.55	0	-
			4588.89	1388.56	30.00

TABLE 10

MINE DRAINAGE POLLUTION: PHYSICAL IMPACT

DRAIN. BASIN NUMBER	DRAINAGE BASIN NAME	PLANNING UNITS	TOTAL STREAM LENGTH (MILES)	PHYSICALLY POLLUTED STREAM LENGTH (MILES)	PERCENT PHYSICAL POLLUTION
33	East and Middle Fork Duck Creek	107,108,118	203.66	86.27	42.36
29	Moxahala Creek	073,074	166.16	81.88	49.28
7	Ohio River Tributaries	043,044	126.38	67.50	53.41
25	West Fork Duck Creek	114,119	178.50	55.31	30.99
14	Shade River	035	142.55	54.57	38.28
20	Monday Creek	052,053,054	269.72	44.60	16.54
16	Raccoon Headwaters	020,021	155.74	38.45	24.69
12	Leading Creek	032,033,034	229.16	36.28	15.83
10	Little Raccoon Creek	018,024,025	113.68	35.56	31.28
28	Rush Creek	059	94.60	35.04	37.04
5	Lower Raccoon Creek	014	84.86	22.92	27.01
21	Sunday Creek	048,050,051	72.68	32.15	44.24
2	Symmes Creek	007,008,009,010,011	289.00	15.92	5.51
4	Pine Creek	003,004	116.77	10.05	8.61
50	McMahon Creek	137,138,139	219.89	8.14	3.70
55	Wheeling Creek	141,142,143,144,145	254.44	7.58	2.97
56	Short Creek	146,148,149,150,151,152	268.49	4.08	1.52
61	Cross Creek	215,216	143.73	0	-
49	Upper Stillwater	156,193,194,195	181.80	0	-
11	Raccoon and Elk Fork	016,017	90.69	0	-
59	Stone Creek	168,169,173	145.65	0	-
64	Conotton Creek	170,172	165.91	0	-
58	Sugar Creek	167,175	136.46	0	-
53	Tuscarawas Tributaries	164,165,166	213.82	0	-
41	Muskingum River Tributaries	081,082	110.98	0	-
66	Yellow Creek	198,199,200,201,202	195.83	0	-
54	Stillwater Creek	162	40.34	0	-
37	Wills Creek	132	54.55	0	-
68	Little Yellow Creek	203	30.97	0	-
47	Lower Wills Creek	126,127,128	91.88	0	-
55	Wheeling Creek	141,142,143,144,145	254.44	7.58	2.97
			4588.89	636.30	13.00

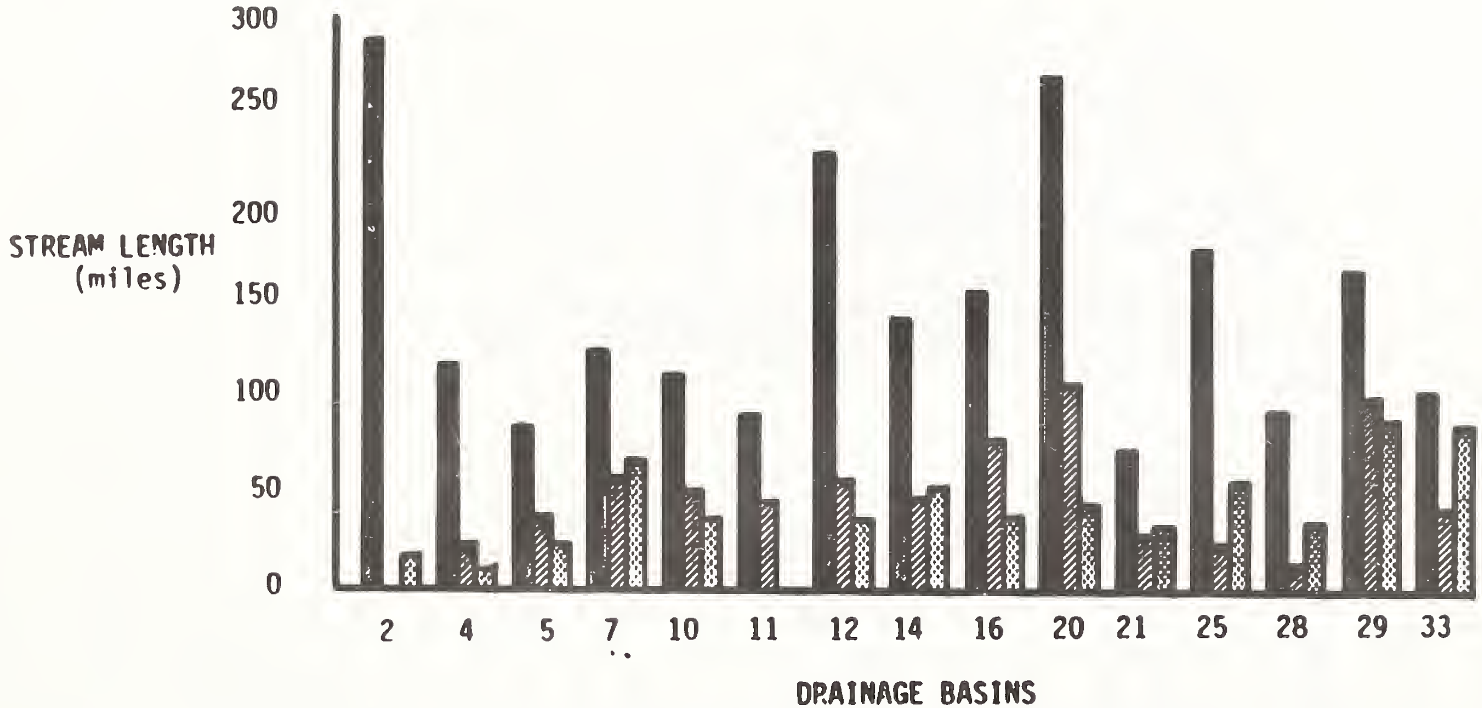
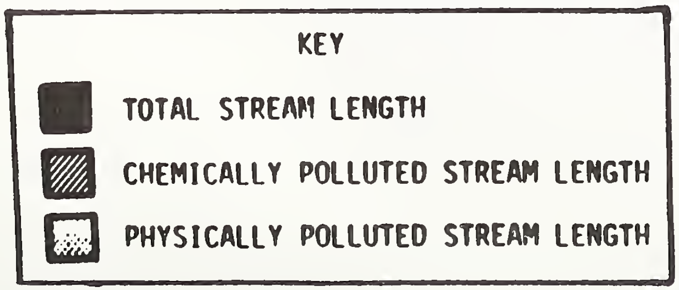


FIGURE 4
QUANTITATIVE MINE DRAINAGE POLLUTION



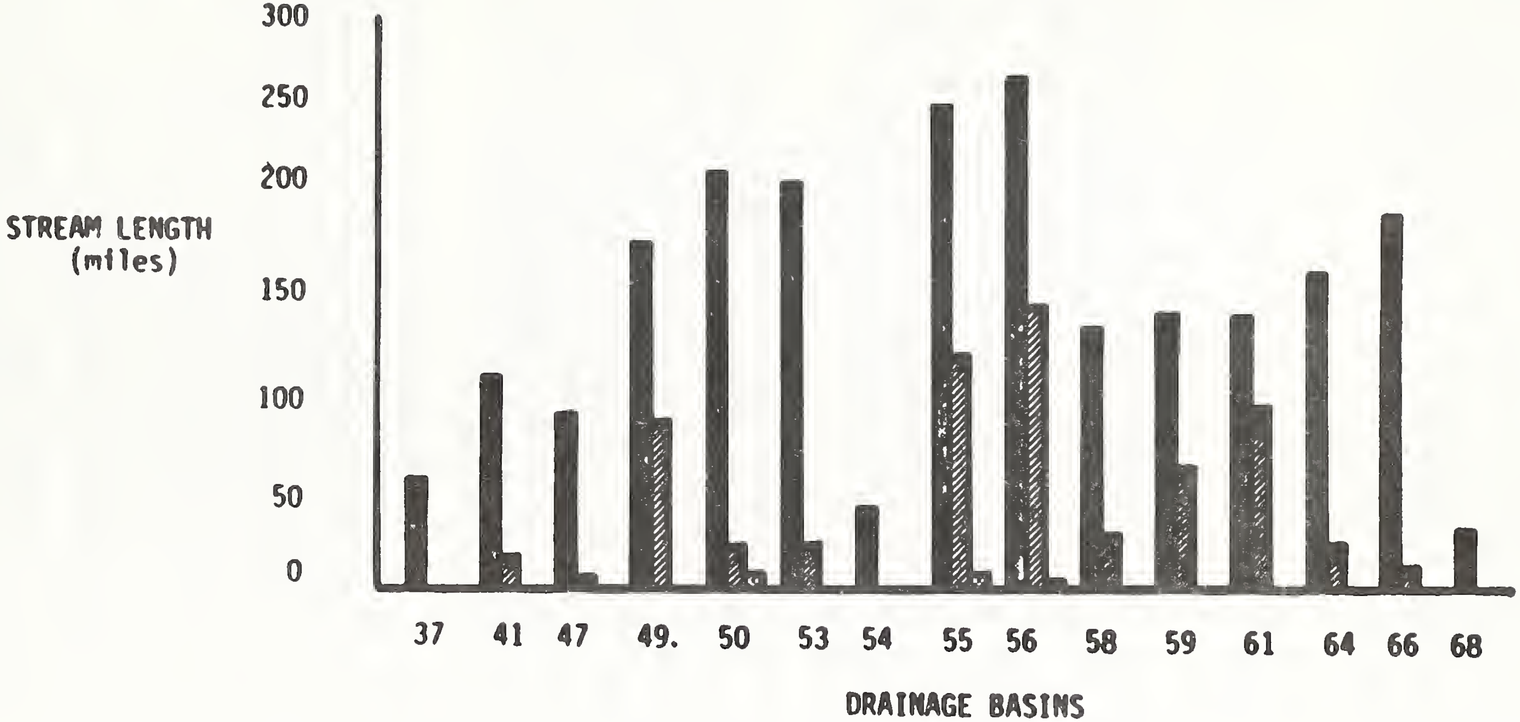
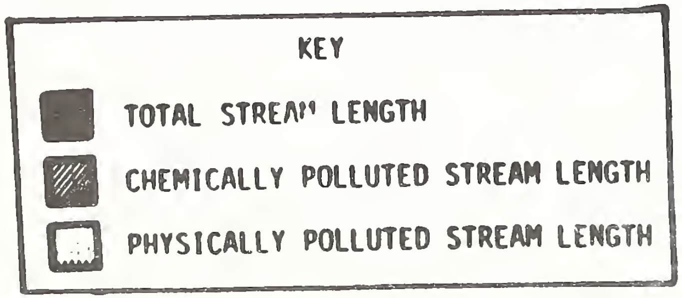


FIGURE 4 (continued)



The qualitative data were plotted on 7.5 minute topographic maps showing surface and underground mines to identify areas contributing to the mine drainage pollution. On-site examination of the areas previously highlighted on the topographic maps was used to isolate the specific source locations of the mine drainage pollution. As a result, 68,000 acres of abandoned strip mines, 79,000 acres of underground mines, and 3,000 acres of mine refuse were pin-pointed as pollution sources. Tables 11, 12, and 13 summarize the source-identification results for each drainage basin.

F. Landslides, Dangerous Impoundments, Visual Pollution, Abandoned Equipment

Much of the topography in Ohio's coal mining region is moderately to steeply sloping. As a result, many of the clay rich soils on these slopes have a high degree of natural instability and often display evidence of landslipping. Mine-related landslides and other forms of mass movement may result when these conditions are combined with poor construction or mining practices, improper support and compaction of spoil or other artificial fill material, excessive vibration, unusually high rates of seepage, or higher than normal ground water levels. Examples of landslides threatening schools, private residences, and public roads in southeastern Ohio have been directly attributed to abandoned mining operations in several Ohio counties.

Abandoned mine-related water impoundments are present in almost all surface coal mined areas of the state. Many are highly acidic and pose unique problems in their reclamation. Others have the potential to be developed into recreational sites for fishing, aquatic habitats, or natural areas. Many impoundments are either severely acidic, toxic with metals and other dissolved materials, structurally unsafe, or attractive nuisances because of their locations. These are usually removed during reclamation of the area. Current inventory studies being completed in the state for the Office of Surface Mining's National Inventory will also be identifying these problem water impoundments.

The barren, eroding landscape of abandoned mined lands is a significant detriment to the character, beauty, and economic standing of a region or community. In addition to drastically reducing adjacent land values, the presence of unvegetated mine sites can severely limit the likelihood of recreational, residential, or industrial development of an adjacent site. This condition is especially true in the case of forested areas where the stripped lands stand out in even greater contrast, a situation reflected in 60 percent of the lands in the coal bearing region of the state.

In addition, abandoned structures and past mining dumping sites contribute further to visual nuisances associated with abandoned mine sites.

Abandoned surface structures and equipment used in past coal handling and processing also present dangers to local residents. Hazardous structures should be eliminated in the course of future reclamation projects.

TABLE 11

MINE DRAINAGE SOURCES: SURFACE MINE ACREAGE

DRAINAGE BASIN NUMBER	DRAINAGE BASIN NAME	SURFACE MINE ACREAGE
49	Upper Stillwater	13,623.59
29	Moxahala Creek	8,307.32
56	Short Creek	6,946.87
33	East and Middle Fork Duck Creek	5,583.08
61	Cross Creek	4,573.10
55	Wheeling Creek	4,157.37
25	West Fork Duck Creek	3,351.06
20	Monday Creek	3,172.26
7	Ohio River Tributaries	2,388.60
64	Conotton Creek	2,252.75
12	Leading Creek	2,009.49
28	Rush Creek	1,923.92
10	Little Raccoon Creek	1,726.25
58	Sugar Creek	1,615.46
14	Shade River	937.86
2	Symmes Creek	896.70
16	Raccoon Headwaters	759.99
4	Pine creek	612.02
5	Lower Raccoon Creek	542.43
41	Muskingum River Tributaries	520.38
59	Stone Creek	469.77
21	Sunday Creek	467.46
11	Raccoon and Elk Fork	435.54
53	Tuscarawas Tributaries	395.69
68	Little Yellow Creek	191.10
66	Yellow Creek	142.16
50	McMahon Creek	46.07
54	Stillwater Creek	0
47	Lower Wills Creek	0
37	Wills Creek	0

TABLE 12

MINE DRAINAGE SOURCES: UNDERGROUND MINE ACREAGE

DRAINAGE BASIN NUMBER	DRAINAGE BASIN NAME	UNDERGROUND MINE ACREAGE
55	Wheeling Creek	15,657.97
56	Short Creek	14,820.77
20	Monday Creek	14,796.94
29	Moxahala Creek	8,484.02
59	Stone Creek	4,991.62
50	McMahon Creek	3,513.30
12	Leading Creek	3,272.22
66	Yellow Creek	3,058.01
53	Tuscarawas Tributaries	2,385.50
21	Sunday Creek	2,012.30
16	Raccoon Headwaters	1,846.01
7	Ohio River Tributaries	809.40
47	Lower Wills Creek	746.97
64	Conotton Creek	604.85
10	Little Raccoon Creek	571.75
49	Upper Stillwater	566.25
58	Sugar Creek	484.16
11	Raccoon and Elk Fork	408.07
4	Pine Creek	149.94
28	Rush Creek	114.66
41	Muskingum River Tributaries	21.20
25	West Fork Duck Creek	5.88
14	Shade River	0
61	Cross Creek	0
2	Symmes Creek	0
33	East and Middle Fork Duck Creek	0
54	Stillwater	0
5	Lower Raccoon Creek	0
68	Little Yellow Creek	0
37	Wills Creek	0

TABLE 13

MINE DRAINAGE SOURCES: MINE REFUSE ACREAGE

DRAINAGE BASIN NUMBER	DRAINAGE BASIN NAME	MINE REFUSE ACREAGE
56	Short Creek	646.80
29	Moxahala Creek	432.19
50	McMahon Creek	418.95
55	Wheeling Creek	391.81
47	Lower Wills Creek	191.10
53	Tuscarawas Tributaries	170.48
66	Yellow Creek	136.13
28	Rush Creek	132.30
59	Stone Creek	128.10
21	Sunday Creek	98.02
16	Raccoon Headwaters	90.26
41	Muskingum River Tributaries	80.85
61	Cross Creek	77.16
64	Conotton Creek	76.12
10	Little Raccoon Creek	75.44
54	Stillwater Creek	29.40
7	Ohio River Tributaries	21.90
11	Raccoon and Elk Fork	19.81
49	Upper Stillwater	18.50
20	Monday Creek	16.17
4	Pine Creek	11.39
12	Leading Creek	3.68
14	Shade River	0
25	West Fork Duck Creek	0
2	Symmes Creek	0
33	East and Middle Fork Duck Creek	0
5	Lower Raccoon Creek	0
68	Little Yellow Creek	0
58	Sugar Creek	0
37	Wills Creek	0

G. Study Objectives

1. To evaluate and supplement existing inventories.

   Input for the study would be obtained from existing inventories held primarily by the Ohio Division of Reclamation, the Office of Surface Mining, the U.S. Geological Survey, the Soil Conservation Service, and U.S. Forest Service. Existing inventories would be supplemented by the thorough updating of the Abandoned Mine Lands National Inventory; by utilizing recent water quality studies performed for the Ohio Division of Reclamation by the U.S. Geological Survey; by special studies conducted by the Soil Conservation Service, Ohio Division of Reclamation, U.S. Forest Service, and Economic Research Service; and from questionnaires returned from a comprehensive system of public meetings.

2. To survey the most severely impacted areas as indicated in previous studies and inventories.

   The overall objective of the proposed study is to identify the most severely impacted abandoned mine sites in the 26 county area and point out areas to be treated. The focal point will be on the 30 watersheds identified by the Ohio Division of Reclamation as having priority over all others for their reclamation efforts.

3. To analyze existing conditions or mined areas and their relationship and/or their environmental and economic impact on downstream areas and/or communities.

   The study would also include the downstream areas directly impacted by abandoned mining operations. Off-site (downstream) impacts related to resources use, water quality, and the environment would be evaluated and quantified.

4. To evaluate and compare proposed alternatives for correction of on and off site problems, technologies, and urgency of treatment.

   The study would establish needs and priorities for alternative treatments and estimate costs for alternative treatments. Consideration will also be given to the technical feasibility of achieving success by the proposed alternative treatments.

5. To develop a ranking and/or priority of impacted areas which are capable of being corrected using existing technology.

The 26 county area would be evaluated on two levels; on a watershed basis and on a planning unit basis. Watersheds selected range in size from approximately 370 square miles (236,800 Ac.) down to 46 square miles (29,440 Ac.) Planning units (PU's) are smaller drainages within a watershed which contain specific problem areas, such as barren eroding strip mine spoil, and impacted areas, such as clogged streams and infertile depositional areas. There is a range of 1 to 6 PU's per watershed. A matrix would be devised which would rank the watersheds and planning units in order of priority for treatment. The ranking would be based on a quantitative evaluation of problems and concerns and their relative impacts on the human and natural environments.

6. To develop cost estimates for needed reclamation in severely impacted areas.

   Cost estimates would be made for identified reclamation needs on a planning unit basis. This information could then be aggregated on a watershed basis or for larger units, if desired.

7. To determine the impacts of alternative strategies for treatment.

   All proven reclamation techniques will be evaluated for their impacts on identified problems in order to demonstrate which techniques are most effective or desirable.

8. Evaluate the feasibility of remining or other resource recovery activities.

   The study would determine the extent of economically recoverable coal or clay recources beneath the orphan mines. Judgments could then be made concerning the probability of a mine being reopened after being reclaimed.

Chapter II - Alternative Treatments

A. Updated Inventories

The National Abandoned Mine Inventory, which was completed by the Ohio Division of Reclamation in cooperation with the Office of Surface Mining, was updated as part of this study. The Problem Area Data Sheets (P.A.D.S.) were reviewed and updated by the SCS field office staffs in each affected county. A supplemental data form was developed to provide additional information regarding land use, land cover, landownership, dangerous impoundments and downstream impacts. There were 357 P.A.D.S. updated and 19 P.A.D.S created to provide information on newly identified problem areas. Data from the updated P.A.D. forms was entered into a computer file which has a comprehensive retrieval capability. Data aggregations were drawn from the system for use in the matrix and in other analyses.

B. Description of Geologic Regional Areas

In order to more clearly define the effectiveness and impacts of alternative treatment strategies, the study area was divided into four geologic regional areas. An understanding of the following regional geologic characteristics is essential for reclamation planning.

The study area occupies a 26 county region in the eastern third of Ohio (Figure 5). This 26 county area is primarily in the unglaciated portion of the State where bedrock of Pennsylvanian and Permian age is exposed. At least sixty identifiable coal seams are present in these rock units; twenty-one have been commercially mined. Only fifteen are mined significantly today. These important seams were numbered upward through the stratigraphic sequence with the oldest (lowest) seams having the lowest numbers.

The Ohio coal field is on the northwestern edge of the Appalachian Coal Basin. As a result, the rock units in Ohio's coal field tilt or "dip" to the southeast. This dip of the rock causes similar rock types to be exposed at the ground surface in bands which cross Ohio in an orientation from southwest to northeast (Figure 5.)

Just as similar rock units occur in bands across southeastern Ohio, so do groupings of similar AML problems. This relationship exists because these problems are controlled by the types of mining techniques used and the chemical and physical characteristics of the rock units exposed during mining, both of which are geologically controlled.

BEDROCK OUTCROP PATTERN

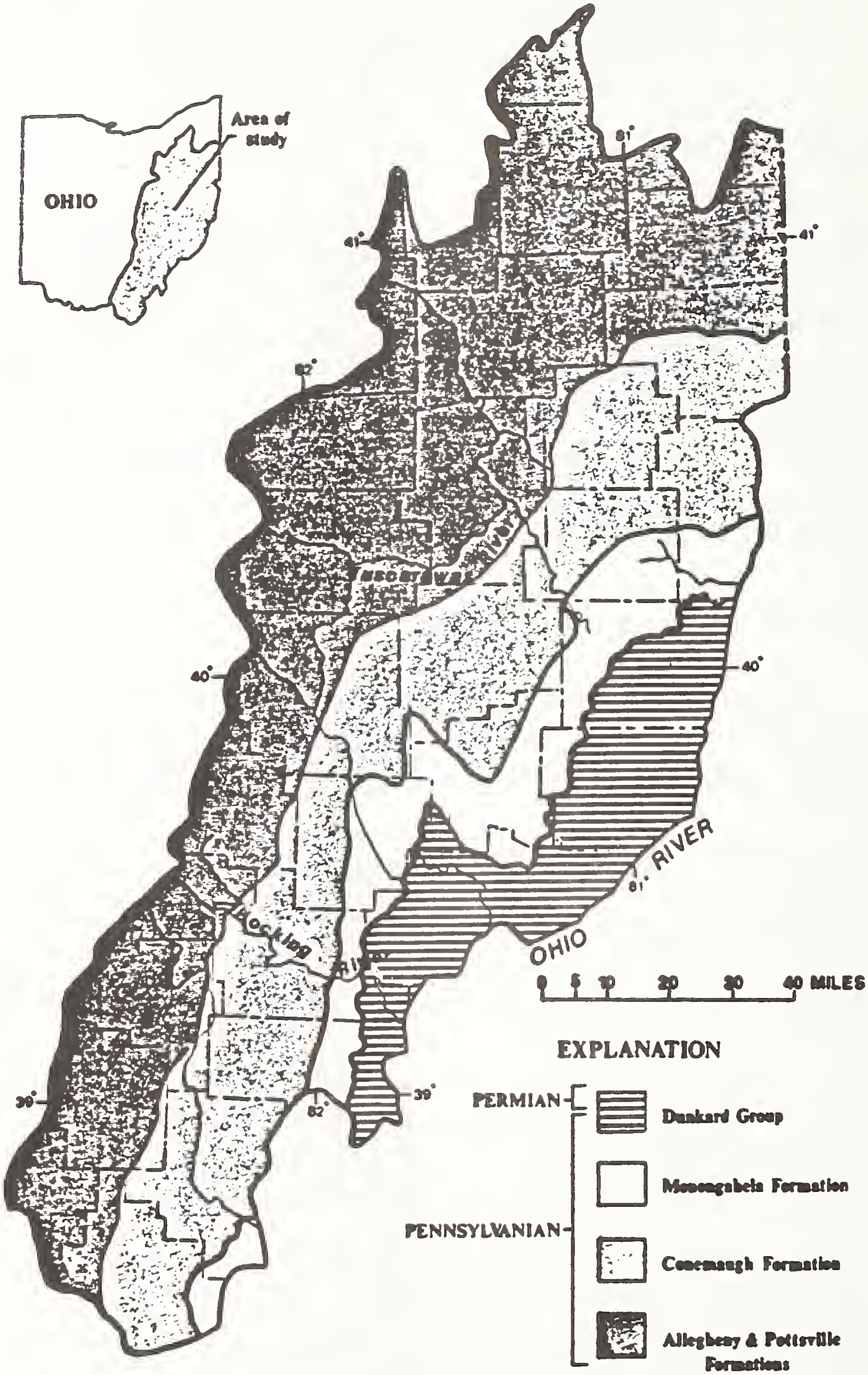


FIGURE 5

Some coal seams such as the Pittsburgh (Number 8) seam are consistently overlain by other rock strata such as limestone which are capable of neutralizing a significant portion of the acid mine drainage produced by mining in that coal seam. This neutralizing material is broken up and mixed into the mine spoil during surface mining. However, acid production by underground mines is not affected by the vicinity of this neutralizing agent because the neutralizing material is not incorporated.

Coal seams having this accompanying neutralizing factor tend to occur in the northern portion of the Ohio coal field north of Interstate I-70. In many of these northern areas, abandoned surface mine spoil is well-vegetated, indicating little or no acid production.

In southern Ohio, these neutralizing agents are not as well developed in lateral extent and thickness, and coal seams such as the Pomeroy (Number 8A) seam have high acid production. Mine spoil from operations in the Pomeroy coal seam is unvegetated, toxic, and eroding.

The combination of southwest to northeast bands of similar rock types and a north-south variation in neutralizing potential in Ohio results in an identifiable pattern in AML problems statewide.

Four geologic areas in Ohio having similar AML problems have been identified in this study (Figure 6). These four areas are oriented in the same southwest to northeast direction as the underlying rock units. Each of the four areas is discussed individually below.

Region 1

This area in the vicinity of Tuscarawas and Coshocton counties is underlain by rocks of lower Pennsylvanian age in the Pottsville and Allegheny groups. Many mineable coal seams occur in this area of which four are important coal producers:

Brookville (Number 4) coal bed	(24" Thick)
Lower Kittaning (Number 5)	(28" Thick)
Middle Kittaning (Number 6)	(28 to 42" Thick)
Upper Freeport (Number 7)	(28 to 42" Thick)

Region 2

This area includes the three main coal-producing counties in Ohio: Harrison, Jefferson, and Belmont counties. The bedrock underlying this area includes the Conemaugh and Monongahela groups of Pennsylvanian age and the Dunkard group of the Permian age.

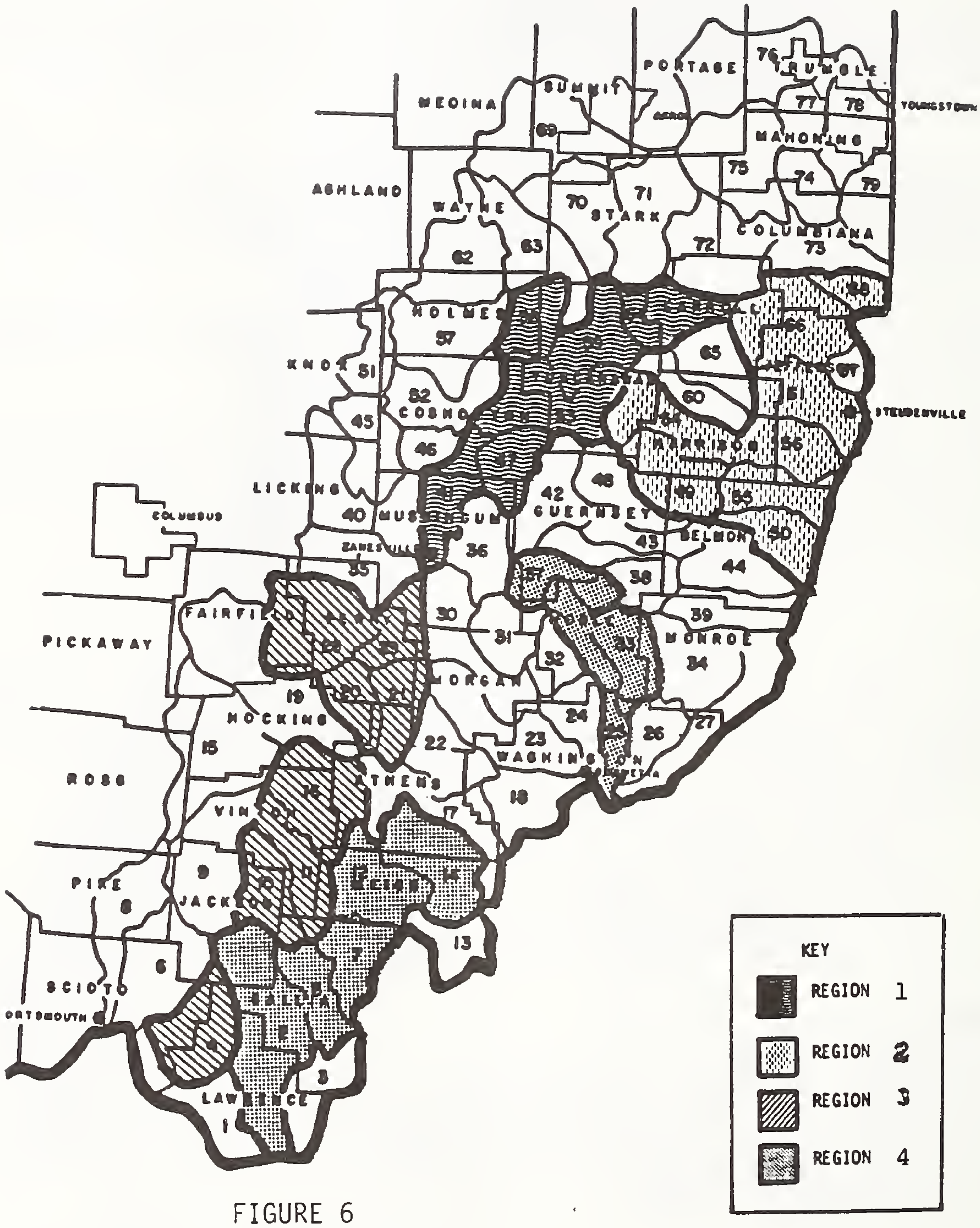


FIGURE 6
GEOLOGIC REGIONAL AREAS

Of the many coal seams in this area, seven are important producers:

Lower Kittaning (Number 5)	(36" Thick)
Middle Kittaning (Number 6)	(28" Thick)
Lower Freeport (Number 6A)	(14 to 54" Thick)
Pittsburgh (Number 8)	(60" Thick)
Meigs Creek (Number 9)	(60" Thick)
Uniontown (Number 10)	(Variable Thickness)
Waynesburg (Number 11)	(26 to 42" Thick)

Region 3

This elongate area runs for approximately 100 miles from eastern Scioto county to southern Muskingum county and includes the most acid-producing areas of the coal region. The underlying bedrock is the Pottsville and Allegheny groups of the Pennsylvanian age with some Conemaugh group rock exposed along the eastern margin of the area.

The main coal-producing seams include the following:

Sharon (Number 1)	(28 to 42" Thick)
Brookville (Number 4)	(28" Thick)
Clarion (Number 4A)	(42 to 54" Thick)
Lower Kittaning (Number 5)	(14 to 28" Thick)
Middle Kittaning (Number 6)	(42" Thick)
Upper Freeport (Number 7)	(14 to 28" Thick)

Region 4

Region 4 is the eastward extension of Region 3 and has the same geologic orientation, but extending from Lawrence county north to Noble county. The lack of significant past mining in Morgan and Washington counties is the cause of the area having two isolated parts.

Bedrock of the Conemaugh and Monongahela groups of Pennsylvanian age primarily underly this area. Minor areas of Allegheny production exist. The main coal-producing seams are as follows:

Lower Kittaning (Number 5)	(28" Thick)
Upper Freeport (Number 7)	(up to 28" Thick)
Pittsburgh (Number 8)	(up to 42" Thick)
Pomeroy (Number 8A)	(28 to 42" Thick)
Meigs Creek (Number 9)	(28 to 42" Thick)

C. Alternative Treatment Methods

1. Resoiling of Mine Spoil

For abandoned coal mine land that is very acidic, sandy, shaley or consisting of coal waste (gob), treatment with lime and/or fertilizer will not be sufficient to establish and maintain vegetation. When such conditions exist, resoiling is a potential method of providing an adequate root zone. Resoiling has been the most widely used alternative treatment method in the study area, where treatment of existing spoil is not feasible.

Resoiling usually consists of removing topsoil and subsoil from an area near the abandoned mine site. Depending upon the proposed land use of the borrow site (where the resoiling material is obtained), the topsoil can be salvaged and re-spread on the borrow site. A six to eight inch layer of soil is usually spread over the abandoned mine spoil to create an adequate rooting zone. Thicker layers of soil are used when covering very toxic sites and/or if the proposed land use of the abandoned mine site is a higher intensive use than wildlife habitat.

Once the mine spoil has been resoiled, fertilizer and/or lime is incorporated into the soil. Then seeding and mulching complete the reclamation process.

Before determining whether to resoil, versus another alternative, one needs to determine if an adequate source of soil is close enough to make it the most feasible choice. Hand augers and backhoes are used to locate suitable borrow sites. A soil depth of at least six feet is preferred on borrow sites to justify their revegetation costs.

2. Preparation and Seeding of Existing Mine Spoil

Most abandoned coal mine lands have uneven surfaces which are gently sloping to very steep. Gullies ranging from 1 to 40 feet deep commonly occur on the mine spoil landscape.

The first step in the reclamation construction process is the grading of the site with bulldozers. They fill the gullies with adjacent spoil and grade steep slopes by cutting and filling to obtain a slope no steeper than 3:1, if feasible. However, there are some areas where grading is not done prior to seeding for the following reasons: (1) the existing slopes are uniform or partly vegetated; or (2) the slopes are short and can be reached with a hydroseeder.

Surface and/or subsurface drains are then installed, if needed, to provide site stability.

The subsurface measures usually consist of perforated tubing, surrounded with gravel, to collect and convey water seeps to waterways. Sometimes only gravel or stone is used without tubing for underground water seepage control. Surface drainage measures can include permanent diversions, straw-bale diversions, grass and stone-centered waterways and rock-lined waterways.

The next phase of reclamation is determined by the type of mine spoil on the site. If the spoil is very acidic, then just applying lime and fertilizer would probably not be a feasible way of providing a suitable environment for plant survival.

On acidic spoils, alternative treatments are usually pursued. (See Resoil and Byproduct sections). For spoils that are slightly acidic, neutral or slightly basic in relation to pH, an adequate growing medium can be obtained by adding fertilizer and/or lime. The amounts of these soil amendments are determined by soil test results.

The application method varies with the available equipment and site specific conditions. Some methods include broadcasting, drilling, and applying amendments with a hydroseeder.

Seeding can include grasses, legumes and/or tree seeds to revegetate the reclaimed areas. Selection of species depends on pH, fertility, slope, drainage and desired land use. A mulch, usually consisting of straw or hay, is then spread over the seed to hold the soil in place and conserve moisture while the plants are getting established.

Regions 1 and 2 are more suited to this treatment since they have generally less acid spoils than regions 3 and 4. Specific sites vary greatly within regions in regard to soil types, however, a 70% success rate is an approximate average for regions 1 and 2. This means that if just lime and/or fertilizer was applied to all the sites in these regions, and then seeded, vegetation establishment would be successful on 70% of the area treated.

The average success rate in region 3 is estimated at 30% using this reclamation method, while region 4 is 15%. The mine spoils that are more shaley and less sandy are generally better suited for this type of treatment.

3. Chemical Application and Seeding
   (papermill sludge, municipal sludge, and fly ash)

These three treatments are the primary alternatives to resoiling, when the mine spoil is too acidic or sandy for treatment with only lime and/or fertilizer. Various rates and sources of each material have been used. The feasibility of using these treatments depends on the source location versus the site location.

Success rates are an average of all these treatments. Highest rates are found in regions 1 and 2 at 90%. Region 3 is rated at 85% and region 4 at 80%. The sludge treatment advantages depends on their nutrient and organic matter content, when compared to fly ash or resoiling.

4. Sediment Traps

Sediment traps are water detention structures, usually formed by a dam, which detain inflowing waters for a period which is long enough to allow for the settlement of water-borne sediments. The amount of sediment trapped depends on the particle fall velocities of the incoming sediment and the detention storage time of the trap or reservoir.

Sediment traps have been used effectively in strip mine reclamation since its inception. They have been used primarily to keep sediments out of receiving waters during the construction and establishment phases of the reclamation effort. Environmental and economic benefits accrue from their use. The use of sediment traps is considered an integral part of the plans and costs for alternatives 1 and 2 ("Resoil of Mine Spoil" and "Preparation and Seeding of Existing Mine Spoil").

Sediment traps were also considered separately from the mine reclamation process. They can be used as an effective measure to trap damaging sediments when other immediate alternatives are unavailable. An example of this concept would be damages caused to agriculture and transportation facilities when a channel aggrades because of sediment deposition. If the eroded mine area is not scheduled for reclamation in the foreseeable future, sediment trap installation may be a cost effective method of preventing sediment damages during the interim period.

The life of a sediment trap is limited by its sediment storage capacity. Once the trap's effective limit has been reached it will allow the sediment load to pass downstream and thus continue the damages. They can, however, be cleaned out if the dredging and disposal operation is deemed cost effective.

These structures are not considered a substitute for reclamation of the land surface because they are temporary and do not solve the massive upstream erosion problem.

5. Channel Work

Many of the streams in the impacted areas have lost a significant portion of their conveyance (water-carrying capacity) due to the deposition of sediment from upstream strip mined areas. In some of the most extreme cases the channel capacity has been reduced by more than 95% from what it was prior to mining. This reduced capacity has resulted in increased flood damages to buildings, agricultural lands, roads, and bridges.

Lost capacity could be temporarily restored by excavation or dredging. However, the excessively high erosion rates in the upstream mined areas cause continued rapid deposition in the channels. Until the mined areas in the watershed are stabilized, channel capacity can not be effectively maintained at its pre-mining level. Major channel work is not practical until upstream sediment sources are treated.

6. Channel Maintenance

Open channels below severely eroding mined areas rapidly lose their ability to convey water unless they are properly maintained. Streams become clogged with vegetation and/or filled with sediment. Annual maintenance is just as important as good design or construction.

The proper sequence of operations for addressing the problem of reduced stream capacity in the impacted areas is to; (1) treat the mined areas in the watershed and stabilize the source of sediment, (2) excavate the channels to restore them to their "pre-mining" capacity, and (3) establish an effective maintenance program. As an interim measure, until steps 1 and 2 can be accomplished, an effort should be made to keep the channels from deteriorating further. This is especially critical around bridges and other structures which are highly susceptible to flood related damages. Removal of log jams and debris, selective clearing of in-channel vegetation, and maintaining the channel opening under bridges are all beneficial.

7. Mine Remaining Coal

Many types of abandoned mined land problems result from incomplete recovery of coal during the original mining operation. Pillars of coal left in underground mines contribute to subsidence problems and the production of acid mine drainage. Impure coal left in surface mine spoil banks plays a part in mine drainage production and the associated problems of erosion and downstream sedimentation.

One reclamation treatment technique is therefore to remove the remaining coal at a problem site. For underground mines this is accomplished by surface mining down to the coal seam and exposing the mine pillars and impure coal for surface removal. This technique is called "daylighting" and is diagrammed in Figure 7. The disadvantages of this method include the large amount of earthmoving and excavation required, the disturbance of any structures or utilities above the underground mine, and potential flooding from water expulsion during collapse. One advantage is that the commercial value of the removed coal can significantly offset the cost of reclamation.

The selective concentration and removal of coal and coal dust ("fines") from surface spoil piles is also important for two reasons. First, a marketable by-product of purified carbon can result from the use of the various types of gravity/settling equipment now available. Removal of the coal from the surface mine spoil or mine wastes will reduce the overall toxicity of the material and its reactivity with water and air in the formation of acid mine drainage. Any program to mine the remaining coal would involve complete site reclamation.

"DAYLIGHTING"

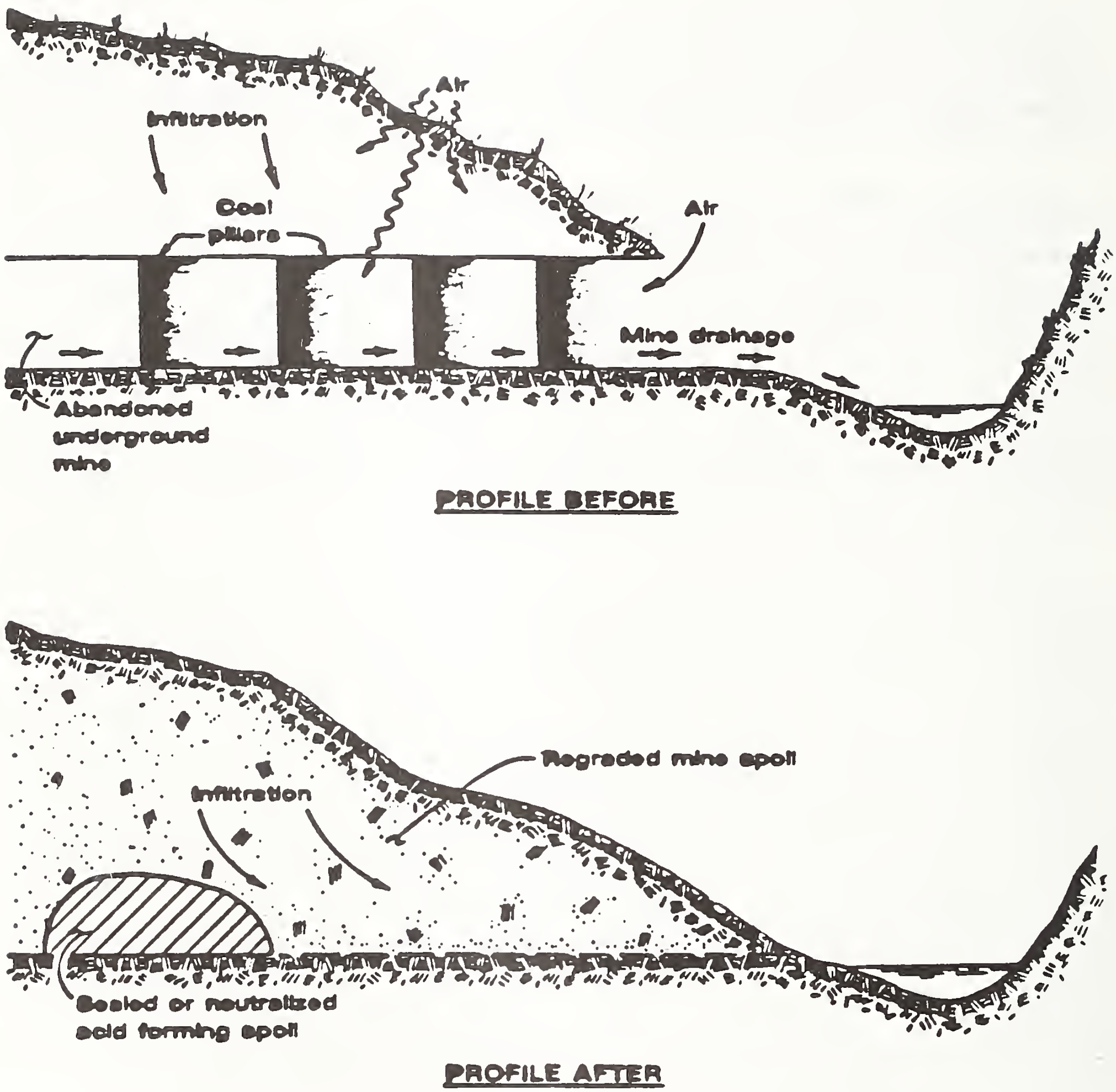


FIGURE 7

8. Cover Mine with Neutralizing Barrier or Impermeable Barrier

In-place neutralization of acid spoils can be achieved by selectively placing them during regrading operations and coating the material with a layer of lime. Following completion of reclamation work, natural infiltration transmits the lime into the acid materials initiating neutralization in-place. Application of this technique is best suited to small volumes of potentially acid material. In some cases clay is utilized instead of lime to seal the toxic waste from water. Clay materials are compacted in six inch lifts until an impervious barrier approximately 2 feet in thickness is achieved. Either of these methods may prove effective in projects where smaller amounts of toxic spoil are encountered.

9. Treatment with Lime

Neutralization of acid mine drainage using lime was greatly utilized during the 1960's. Today, as a result of high costs and inefficient results, lime is seldom used as a water treatment for AMD streams.

10. Seal Deep Mines

Underground mines pose problems from subsidence, dangerous mine entries, and the production of acid mine drainage. One technique to control mine drainage production from underground mines is to seal all discharge points from the mines, thus flooding the mine workings. This flooding cuts off the supply of oxygen to the exposed coal in the mines and significantly reduces mine drainage production.

Mine sealing is generally accomplished by one or more of four techniques:

1. Installation of clay plugs at distinct mine entries (Figures 10 and 11);

2. Construction of slurry trenches along the outcrop of discharging coal seams (Figures 8 and 9);

3. Excavation and emplacement of a clay blanket along a coal seam outcrop (Figure 10); and

4. Drilling and injection of double bulkhead seals (Figure 12).

Each of these techniques is costly, either from needed excavation, drilling, trenching, or careful material handling. Further, these techniques are often rendered ineffective by mine leakage at other locations or leakage around the mine seal material.

DEEP MINE SEALING

FIGURE 8

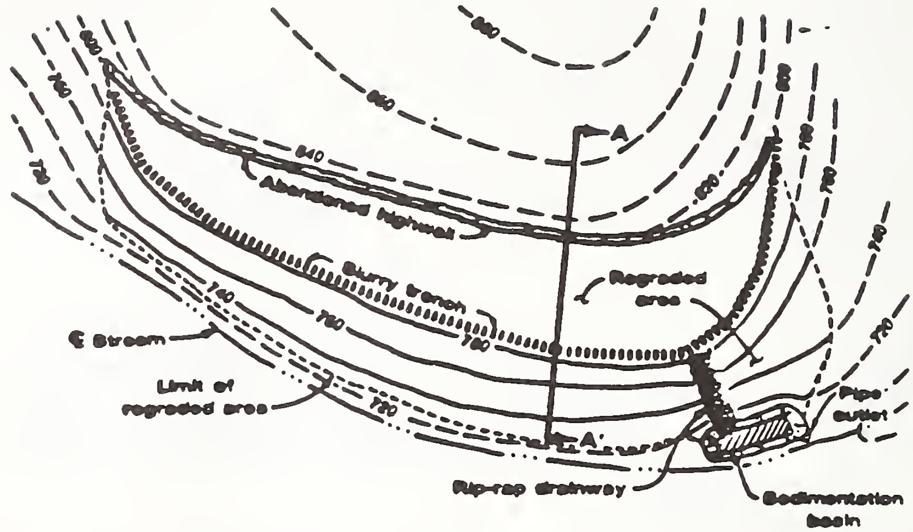


FIGURE 9

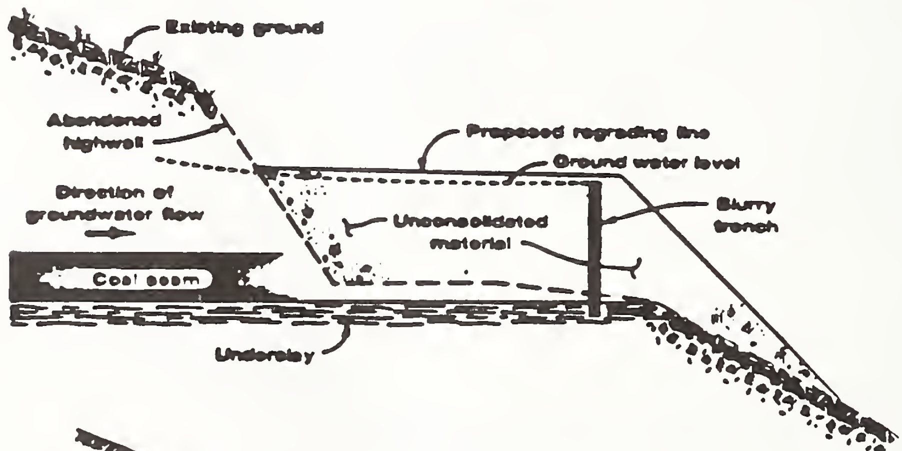
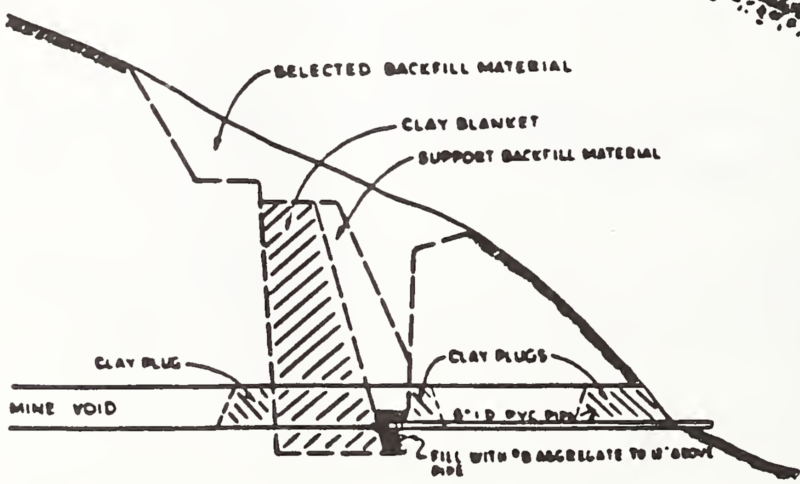


FIGURE 10



DEEP MINE SEALING

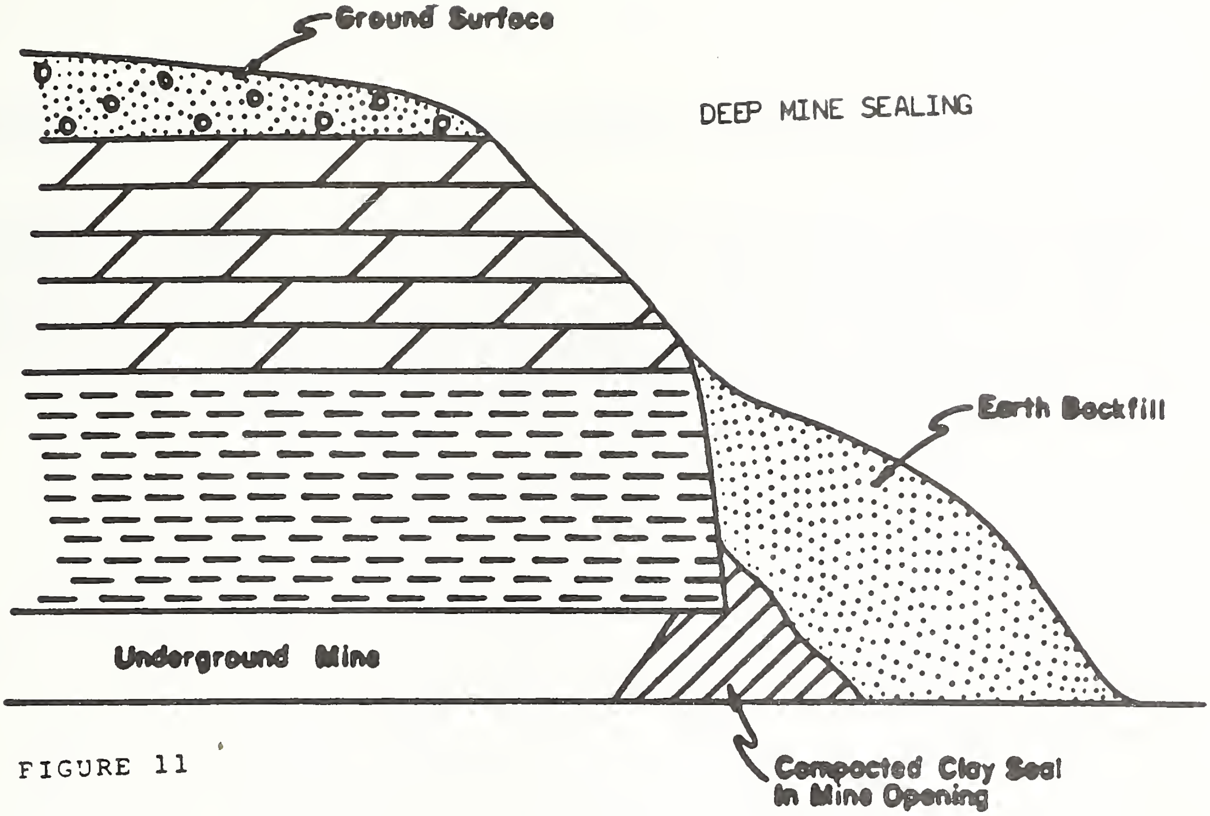
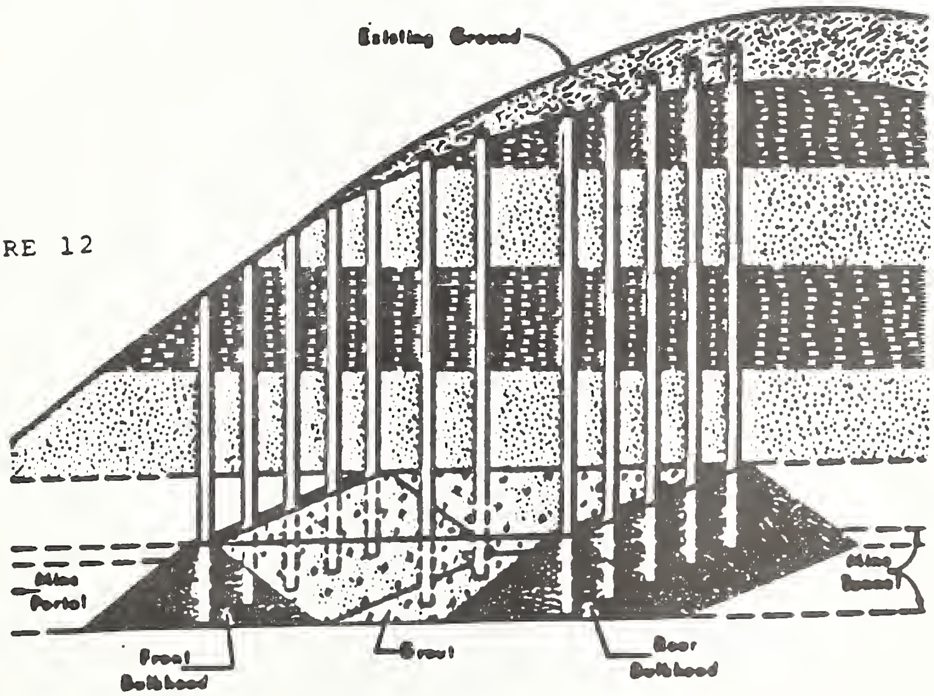


FIGURE 11

FIGURE 12



CROSS SECTION OF
DOUBLE BULKHEAD SEAL

D. Effectiveness of Alternative Treatment Methods in Reducing On-Site Problems

The ten physical alternative treatment methods were evaluated to determine their relative effectiveness in reducing on-site problems of erosion, sedimentation, flooding, loss of useful land, and water quality. Table 14 presents the percent effectiveness of each alternative (vertical columns) in reducing specific on-site problems (horizontal columns). A discussion of each problem and the merits of applicable alternative solutions to reduce the problem follows the table.

TABLE 14

Percentage of Effectiveness of Alternative Treatment Methods in Reducing On-Site Problems

	Resoiling (%)	Preparation and Seeding (%)	Chemical Application and Seeding (%)	Sediment Traps (%)	Channel Work (%)	Channel Maintenance (%)	Mine Remaining Coal (%)	Cover Mine With Impermeable Material (%)	Water Treatment With Lime (%)	Seal Deep Mines (%)
EROSION										
Regions 1 & 2	90	90	85	75	0	0	90	0 - 90	0	0
Regions 3 & 4	90	90	85	75	0	0	90	0 - 90	0	0
SEDIMENTATION										
Regions 1 & 2	90	90	85	75	0	0	90	0 - 95	0	0
Regions 3 & 4	90	90	85	75	0	0	90	0 - 95	0	0
FLOODING										
Regions 1 & 2	10	10	10	2	5	5	0	5	0	0
Regions 3 & 4	10	10	0	2	35	15	0	5	0	0
LOSS USEFUL LAND										
Region 1	95	70	90	0	0	0	95	0 - 90	0	0
Region 2	95	70	90	0	0	0	95	0 - 90	0	0
Region 3	95	30	85	0	0	0	95	0 - 90	0	0
Region 4	95	15	80	0	0	0	95	0 - 90	0	0
WATER QUALITY	10	10	10	30	10	10	90 - 100	90 - 100	80	90 - 100

Erosion, Sedimentation, and Flooding

Resoiling and preparation and seeding of existing spoils show a significant impact (90%) on the reduction of both erosion and sedimentation. Resoiling is applicable to those sites where the acidity of the mine spoil is too great to effectively neutralize with lime applications. Preparation and seeding of the mine spoils pertains to sites predominantly in the northern portions of Regions 1 and 2, which possess neutral to slightly acid spoils.

Chemical application (anionic surfactants, lime, fertilizer) and seeding applies to sites in the northern portion of Regions 1 and 2 and to isolated sites in the remainder of all regions. Applicable sites have slightly acid to neutral spoils which are relatively smooth and not affected by extensive rill or gully erosion. Erosion and sedimentation reductions are in the range of 70% when vegetation is established. Rills and other erosional features still exist and repeated applications of surfactant are necessary to retard acid production.

These changes (Alternatives 1, 2, and 3) would impact the hydrologic condition of the watershed by improving the cover and therefore reducing the volume of runoff. Some of this change would be offset, however, by improved waterways and flow paths and therefore reduced times of concentration.

Sediment traps are impoundments which detain surface runoff for periods long enough to allow sediments to settle out of suspension. They are utilized to keep sediment out of receiving waters where damages are likely. Sediment traps have been used in surface mine reclamation since its inception to detain existing and construction related sediment. The amount of sediment trapped compared with the total incoming sediment load has been termed the "trap efficiency" of a particular sediment trap. Sediment traps used in reclamation work vary in efficiency from 60 to 90 percent, with 75 percent being typical.

As sediment traps accumulate sediments their capacity decreases resulting in a lower and lower trap efficiency. Eventually the trap becomes so full of sediment that it must be cleaned out or completely discounted as a benefit to receiving waters. Most sediment traps which are associated with surface mine reclamation lose a high proportion of their capacity during the construction process.

Sediment traps are considered an integral part of all surface mine reclamation plans involving the "Resoiling" and "Preparation and Seeding" alternatives.

Sediment traps are considered as an independent measure in cases of severe on-going sediment damage when reclamation of mined areas is not immediately forthcoming. An example of this would be a planning unit with severe surface mine spoil and gob pile erosion which is causing a downstream reach of channel to aggrade. A temporary sediment trap or traps could be installed to alleviate downstream damages to the channel pending reclamation of the mine itself.

A minor amount of flood storage is a part of most sediment traps. This storage would be relatively minor (2%) for most watersheds.

Channel work and channel maintenance are not effective methods of alleviating either the erosion or sedimentation process in mine related reclamation. Channel work, which is accomplished before upstream reclamation of strip mined areas is complete, is a temporary wasted effort. Mine related sediments quickly replace their excavated counterparts thus continuing the original problem. Studies are beginning to show that when upstream reclamation on orphan strip mines is complete, and sediment sources are cut off, the receiving channels begin to degrade. Hopefully, this phenomenon will serve to restore major portions of aggraded channels to a condition where they can be effectively managed as a productive natural resource.

Based on the five sample watersheds studied in detail, it can be concluded that channel work and channel maintenance in regions 3 and 4 would be most effective in reducing flooding. The reduction in regions 1 and 2 is considerably less due to the relative difference in magnitude of the problem.

Strip mining the coal remaining after previous deep and strip mining operations would be approximately 90% effective in reducing erosion and sedimentation problems. This is possible because any new mining would involve the effective reclamation of the site or sites under existing State law. Reclamation of surface mines would probably involve either resoiling, preparation and seeding of existing spoil, or a combination of both.

Deep mining of remaining coal reserves would not have a significant impact per-se on either erosion or sedimentation as performed under recent legislation. Erosion and sedimentation problems from deep mining arise from the erosion and transportation of "gob", which would be prevented by law in any new mining operation.

Covering a mined area with an impervious blanket of clay to prevent water infiltration into deep mines would have a significant effect on erosion and sedimentation. Assuming that a portion of the area covered was barren and severely eroding, the method could reduce erosion and sedimentation by approximately 95%.

If the area covered and revegetated was in good hydrologic condition before using this technique, soil loss and sedimentation reductions would be negligable or very slight. This alternative would provide the same benefits in reducing runoff and flooding as would alternatives 1, 2, and 3. However, these changes would be offset somewhat by the decrease in soil permeability from the compacted clay blanket.

Treatment of stream or deep mine discharges with lime has no impact on identified erosion and sedimentation problems. It does, however, neutralize the chemical sulphuric acid in the water. The calcium sulphate precipitate can cause localized environmental problems if it is allowed to enter the stream system.

Sealing the water discharge from deep mines has virtually no impact on identified erosion and sedimentation problems. Discharge from deep mines normally is sediment free ground water which contains chemicals in solution.

Alternatives 7, 9, and 10 will have no effect on the flood problem.

Loss of Useful Land

Alternatives 1, 2, 3, 7, and 8 have a positive effect on the reclamation of useless eroding barren strip mined lands. These alternatives involve a common effort, to stabilize and revegetate barren eroding mined acres.

Their individual effectiveness depends upon the type of alternative treatment and the initial condition of the mined area as governed to a great extent by its geologic region.

Resoiling, chemical application and seeding, and mining remaining coal all involve very effective reclamation techniques which are applicable in all geologic regions. The preparation and reseeding alternative and the cover with impermeable material alternative are dependent on specific site conditions and controlled to a great extent by the geologic region, and local availability of the artificial resoiling medium.

Alternatives 1, 2, 3, 7, and 8 may also have a positive impact on the eventual stabilization of downstream sedimentation areas and associated aggraded channels. As the sediment source areas are stabilized, aggraded channels below them are expected to degrade. Recent unpublished studies by the U.S. Geological Survey show that this phenomenon is already occurring below several reclaimed sites in the Shade River Watershed. This phenomenon should lead to natural improvements in surface and subsurface flood plain drainage, which will be a major step toward their reclamation.

Sediment traps, channel work, and channel maintenance are temporary measures which under 1985 conditions would have no long-term effect on recovering the loss of useful downstream lands.

Water treatment with lime and sealing deep mines would have little impact on the recoverability of useful land.

Water Quality

Resoiling the mine spoil will have a minor effect on water quality. Sedimentation would be reduced greatly but acid mine drainage would remain.

Preparation and seeding of existing mine spoil will help control erosion once the vegetation is established; however, this will not improve the chemical water quality.

Chemical application and reseeding will provide a form of erosion control but will not improve the chemical mine drainage associated with the spoil material.

Sediment traps control sediment from going further downstream; they do not improve water quality or provide a solution to mine drainage.

Channel work has no impact on water quality.

Channel maintenance may remove sediment from a specific area but it does not affect the chemical mine drainage in the stream.

Mining the remaining coal removes the source of acid mine drainage and therefore improves water quality.

Impermeable material will prevent water from leaching through the spoil material and consequently improve the water quality.

Treating water with lime will improve the chemical quality of the stream. This process is rarely used except when treating impoundment water drained from the mined area.

Sealing deep mines will greatly improve water quality; however, it is often ineffective due to leakage around the mine seal or at other locations in the mine.

E. Priority of Treatment Needs

1. Planning Unit Evaluation Matrix

In order to provide a ranking and priority system for the 78 planning units and 30 watersheds, a comprehensive matrix was developed and adapted to a computer system. The matrix was designed to digest input from the massive amount of inventory data generated during Phases I and II of the study. Data input was categorized into four major areas of concern; general, agriculture, environmental, and mining. These categories were further broken down by subject. (See matrix). Both qualitative and quantitative parameters were used to define the impact of each subject.

Parameters ("stream flow", "chemical pollution", etc.) were assigned a raw score (from 0 to 3) based on the relative magnitude of their adverse impact on the applicable subject ("water resource", etc.). Weighting factors (1-6) were assigned to the raw scores for each parameter to reflect the magnitude of adverse impact of that parameter on the major category ("environmental", etc.).

The basic unit of evaluation was the planning unit or "P.U.". The planning units contain problem areas or "P.A.'s" which are smaller areas from which the parameter measurements were taken. A Total of 376 problem areas were studied within the 78 planning units (4.8 PA's per P.U. on the average). The largest unit of evaluation was the watershed, of which there are 30. There was a range of 1 to 6 planning units per watershed, with the typical being 2 to 3.

The matrix software was designed to aggregate point totals and provide numerical rankings at the planning unit and watershed levels by: area of concern; subject; parameter; and overall. This versatility was built in to serve decisionmakers who must deal with different mixes of concerns, subjects, and parameters.

Planning Unit Evaluation Matrix

Areas of Concern	0	1	2	3	Weighting Factor
GENERAL					
Affected Population					
Number of Inhabitants	none	1 - 99	100 - 499	500	4
Income level	none	$6,500	$5,500 - $6,500	$5,500	1
Unemployment Rate	none	14.0	14 - 16	16.0	1
Health, Safety and Welfare					
Number of Sites	none	1 - 5	6 - 15	over 16	6
Degree of Danger (Eligible Lands)	Priority 3	Priority 2	Priority 1	Emergency	6
Potential Damages					
Transportation and Utilities	$1,000	$1,000 - $24,999	$25,000 - $74,999	$75,000	6
Residential, Commercial and Industrial	$1,000	$1,000 - $24,999	$25,000 - $74,999	$75,000	6
AGRICULTURE					
Mined Area					
Acreage Affected	less than 10 ac.	10 - 100 ac.	100 - 500 ac.	over 500 ac.	4
Property Ownership	none	less than 10% priv.	10 - 90% priv.	over 90% priv.	2
Loss of Useful Land	less than 10 ac.	10 - 25 ac.	26 - 50 ac.	over 50 ac.	2
Land Use Change	less than 10 ac.	10 - 100 ac.	100 - 500 ac.	over 500 ac.	2
Production and Income	$10,000	$5,000 - $9,999	$1,000 - $4,999	$1,000	3
Downstream Impact Area					
Acreage Affected	less than 10 ac.	10 - 100 ac.	100 - 500 ac.	over 500 ac.	6
Property Ownership	none	less than 10% priv.	10 - 90% priv.	over 90% priv.	2
Loss of Useful Land	less than 10 ac.	10 - 25 ac.	26 - 50 ac.	over 50 ac.	4
Land Use Change	less than 10 ac.	10 - 100 ac.	100 - 500 ac.	over 500 ac.	4
Production and Income	$50,000	$25,000 - $49,999	$5,000 - $24,999	$5,000	5

Planning Unit Evaluation Matrix (Continued)

Areas of Concern	0	1	2	3	Weighting Factor
ENVIRONMENTAL					
Water Resource					
% Stream Length Polluted 1/	8.10	8.11 - 30.75	30.76 - 52.00	52.01	6
% Chemical Pollution 2/	10.00	10.01 - 100.00	100.01 - 200.00	200.01	6
% Physical Pollution 3/	1.0	1.10 - 12.50	12.50 - 32.75	32.76	6
Land Resource					
Erosion, Total	10,000 tons/yr.	10 - 25,000 tons/yr.	25 - 50,000 tons/yr.	50,000 tons/yr.	6
Soil Loss, per acre	10 tons/ac./yr.	10 - 24 tons/ac./yr.	24 - 49 tons/ac./yr.	49 tons/ac./yr.	6
Sediment Damage	none	none	0.1 - 1 ft.	over 30%, 1 - 3 ft.	6
Acreage of Deposition	5 ac.	5 - 25 ac.	25 - 100 ac.	100 ac.	6
MINING					
Present Development					
Source Acres:					
Surface Mines	60.0	60.01 - 400.00	400.01 - 1,400.00	1,400.00	4
Underground Mines	50.0	50.01 - 525.00	525.01 - 2,500.00	2,500.00	2
Potential Development					
Remining Feasibility (Coal Reserves X 10^6 Tons)	325	326 - 520	521 - 1,000	1,001	2
					106

1/ % Stream length polluted = $\frac{\text{total chemically and physically polluted stream mileage}}{\text{total stream mileage}}$

2/ % Chemical pollution = $\frac{\text{total chemically polluted stream mileage}}{\text{total stream mileage}}$ X water quality parameter

3/ % Physical pollution = $\frac{\text{total physically polluted stream mileage}}{\text{total stream mileage}}$

2. Effects of Matrix Run by Specific Categories

Matrix evaluations were run to determine the priority rankings of the 30 watersheds based on impacts relating to the four study categories: general; agriculture; environment; and mining. Tables 15, 16, 17, and 18 present the four study categories with: priority rankings; the geologic region[1/] the watershed lies in; the number of planning units (PU's) evaluated per watershed; and the raw matrix score. A discussion of the rankings follows the table.

1/ Refer to Map of Geologic Regions (Figure 6).

TABLE 15

Matrix Ranking By Watershed - General Category

Rank	Watershed	Watershed Name	PU's	Geologic Region	Total
1	55	Wheeling Creek	5	2	183
2	12	Leading Creek	3	4	138
3	10	Little Raccoon Cr.	3	3	132
4	56	Short Cr. & Ohio River Trib.	6	2	130
5	7	Ohio River Trib.	2	4	128
6	33	East & Middle Forks Duck Creek	3	4	105
7	25	West Fork Duck Cr.	2	4	100
8	2	Symmes Creek	5	4	97
9	66	Yellow Creek	5	2	96
10	21	Sunday Creek	3	3	94
11	20	Monday Creek	3	3	91
12	49	Upper Stillwater Cr.	4	2	83
13	29	Moxahala Creek	2	3	79
14	16	Raccoon Cr. Headwtrs	2	3	79
15	59	Stone Creek	3	1	76
16	4	Pine Creek	2	3	70
17	14	Shade River	1	4	66
18	53	Tuscarawas Trib.	3	1	64
19	50	McMahon Creek	3	2	59
20	5	Lower Raccoon	1	4	59
21	28	Rush Creek	1	3	54
22	64	Conotton Creek	2	1	48
23	41	Muskingum Trib.	2	1	37
24	47	Lower Wills Creek	3	1	36
25	11	Raccoon Cr. & Elk Fork Raccoon Cr.	2	3	32
26	61	Cross Creek	2	2	31
27	58	Sugar Creek	2	1	28
28	68	Little Yellow Creek	1	2	21
29	37	Buffalo Fork - Wills Creek	1	4	21
30	54	Stillwater Creek	1	2	14

TABLE 16

Matrix Ranking By Watershed - Agriculture Category

Rank	Watershed	Watershed Name	PU's	Geologic Region	Total
1	55	Wheeling Creek	5	2	236
2	12	Leading Creek	3	4	214
3	49	Upper Stillwater Cr.	4	2	203
4	56	Short Cr. & Ohio River Trib.	6	2	199
5	33	East & Middle Forks Duck Creek	3	4	189
6	10	Little Raccoon Cr.	3	3	183
7	2	Symmes Creek	5	4	180
8	7	Ohio River Trib.	2	4	157
9	29	Moxahala Creek	2	3	150
10	25	West Fork Duck Cr.	2	4	147
11	59	Stone Creek	3	1	124
12	53	Tuscarawas Trib.	3	1	116
13	66	Yellow Creek	5	2	106
14	21	Sunday Creek	3	3	100
15	4	Pine Creek	2	3	93
16	14	Shade River	1	4	92
17	16	Raccoon Cr. Headwtrs	2	3	91
18	64	Conotton Creek	2	1	91
19	20	Monday Creek	3	3	90
20	28	Rush Creek	1	3	79
21	50	McMahon Creek	3	2	75
22	5	Lower Raccoon	1	4	69
23	47	Lower Wills Creek	3	1	57
24	58	Sugar Creek	2	1	56
25	11	Raccoon Cr. & Elk Fork Raccoon Cr.	2	3	50
26	61	Cross Creek	2	2	50
27	41	Muskingum Trib.	2	1	48
28	37	Buffalo Fork - Wills Creek	1	4	35
29	54	Stillwater Creek	1	2	25
30	68	Little Yellow Creek	1	2	21

TABLE 17

Matrix Ranking By Watershed - Environment Category

Rank	Watershed	Watershed Name	PU's	Geologic Region	Total
1	12	Leading Creek	3	4	264
2	33	East & Middle Forks Duck Creek	3	4	252
3	7	Ohio River Trib.	2	4	240
4	21	Sunday Creek	3	3	222
5	10	Little Raccoon Cr.	3	3	222
6	29	Moxahala Creek	2	3	216
7	49	Upper Stillwater Cr.	4	2	198
8	56	Short Cr. & Ohio River Trib.	6	2	186
9	55	Wheeling Creek	5	2	168
10	25	West Fork Duck Cr.	2	4	156
11	20	Monday Creek	3	3	120
12	14	Shade River	1	4	114
13	16	Raccoon Cr. Headwtrs	2	3	114
14	28	Rush Creek	1	3	96
15	59	Stone Creek	3	1	90
16	5	Lower Raccoon	1	4	84
17	64	Conotton Creek	2	1	78
18	53	Tuscarawas Trib.	3	1	72
19	11	Raccoon Cr. & Elk Fork Raccoon Cr.	2	3	66
20	61	Cross Creek	2	2	60
21	58	Sugar Creek	2	1	54
22	47	Lower Wills Creek	3	1	48
23	4	Pine Creek	2	3	48
24	50	McMahon Creek	3	2	48
25	2	Symmes Creek	5	4	36
26	41	Muskingum Trib.	2	1	30
27	66	Yellow Creek	5	2	24
28	68	Little Yellow Creek	1	2	12
29	37	Buffalo Fork - Wills Creek	1	4	6
30	54	Stillwater Creek	1	2	0

TABLE 18

Matrix Ranking By Watershed - Mining Category

Rank	Watershed	Watershed Name	PU's	Geologic Region	Total
1	56	Short Cr. & Ohio River Trib.	6	2	70
2	55	Wheeling Creek	5	2	66
3	20	Monday Creek	3	3	48
4	49	Upper Stillwater Cr.	4	2	48
5	12	Leading Creek	3	4	46
6	29	Moxahala Creek	2	3	46
7	33	East & Middle Forks Duck Creek	3	4	38
8	10	Little Raccoon Cr.	3	3	36
9	7	Ohio River Trib.	2	4	36
10	58	Sugar Creek	2	1	30
11	47	Lower Wills Creek	3	1	30
12	59	Stone Creek	3	1	30
13	53	Tuscarawas Trib.	3	1	30
14	25	West Fork Duck Cr.	2	4	28
15	50	McMahon Creek	3	2	26
16	4	Pine Creek	2	3	24
17	61	Cross Creek	2	2	24
18	16	Raccoon Cr. Headwtrs	2	3	24
19	41	Muskingum Trib.	2	1	22
20	28	Rush Creek	1	3	20
21	21	Sunday Creek	3	3	20
22	64	Conotton Creek	2	1	20
23	11	Raccoon Cr. & Elk Fork Raccoon Cr.	2	3	18
24	66	Yellow Creek	5	2	18
25	14	Shade River	1	4	14
26	5	Lower Raccoon	1	4	12
27	2	Symmes Creek	5	4	12
28	68	Little Yellow Creek	1	2	10
29	37	Buffalo Fork - Wills Creek	1	4	2
30	54	Stillwater Creek	1	2	2

General Category Ranking:

Regional distribution of priority sites is basically random. Watersheds with the highest number of planning units appear to dominate the top ten rankings.

Agriculture:

Regional distribution of priority sites is randomly distributed between regions 2, 3, and 4, with region 1 showing the lowest aggregate rankings. The impact on agriculture in region 1 is therefore less than in the other regions. Watersheds with the highest number of planning units appear to dominate the top ten rankings.

Environment:

Regions 2, 3, and 4 dominate the top ten rankings. The number of planning units per watershed is relatively random throughout the sample. Region 1 appears to have fewer adverse environmental impacts than the other three regions.

Mining:

Present mining development and potential mining development appears to have the greatest impact in regions 2, 3, and 4. Rankings do not appear to be controlled by the number of planning units per watershed.

3. Effects of Matrix Run Overall

Matrix evaluations were run to determine the priority ranking of all 30 watersheds based on their individual total scores for all four study categories: general; agriculture; environmental; and mining. Table 19 presents the overall matrix score for each watershed along with priority rankings, the geologic region, and the number of planning units evaluated in each watershed.

In the overall ranking, regions 2, 3, and 4 dominate the top ten rankings. It also appears that the number of planning units per watershed has a positive influence on the total matrix score.

TABLE 19

Overall Matrix Ranking By Watershed

Rank	Watershed	Watershed Name	PU's	Geologic Region	Total
1	12	Leading Creek	3	4	662
2	55	Wheeling Creek	5	2	653
3	56	Short Cr. & Ohio River Trib.	6	2	585
4	33	East & Middle Forks Duck Creek	3	4	584
5	10	Little Raccoon Cr.	3	3	573
6	7	Ohio River Trib.	2	4	561
7	49	Upper Stillwater Cr.	4	2	532
8	29	Moxahala Creek	2	3	491
9	21	Sunday Creek	3	3	436
10	25	West Fork Duck Cr.	2	4	431
11	20	Monday Creek	3	3	349
12	2	Symmes Creek	5	4	325
13	59	Stone Creek	3	1	320
14	16	Raccoon Cr. Headwtrs	2	3	308
15	14	Shade River	1	4	286
16	53	Tuscarawas Trib.	3	1	282
17	28	Rush Creek	1	3	249
18	66	Yellow Creek	5	2	244
19	64	Conotton Creek	2	1	237
20	4	Pine Creek	2	3	235
21	5	Lower Raccoon	1	4	224
22	50	McMahon Creek	3	2	208
23	47	Lower Wills Creek	3	1	171
24	58	Sugar Creek	2	1	168
25	11	Raccoon Cr. & Elk Fork Raccoon Cr.	2	3	166
26	61	Cross Creek	2	2	165
27	41	Muskingum Trib.	2	1	137
28	37	Buffalo Fork -	1	4	64
29	68	Little Yellow Creek	1	2	64
		Wills Creek			
30	54	Stillwater Creek	1	2	41

Matrix evaluations were also run overall to determine the priority rankings of the 78 planning units independent of their respective watersheds. Planning units, the smallest units for which rankings were computed, consist of smaller specific problem areas (P.A.'s). Three hundred and seventy-six problem areas were inventoried during the course of the study in order to evaluate the 78 planning units. The planning unit is the level at which the interaction of problems, impacts, and solutions are most readily identifiable.

Table 20 lists the planning units, their rank, and their raw matrix score. A discussion of the rankings follows the table.

TABLE 20

Overall Ranking By Planning Unit

Rank	Region	PU's	Total	Name
1	4	44	304	Kyger Creek
2	3	73	292	Upper Moxahala
3	4	35	286	West Branch Shade River
4	4	107	265	Middle Fork Duck Creek
5	3	25	265	Middle Little Raccoon
6	4	43	257	Campaign Creek
7	4	114	252	Lower Duck Creek
8	3	59	249	Upper Rush Creek
9	4	34	243	Thomas Fork
10	4	32	238	Lower Leading Creek
11	4	14	224	Lower Raccoon Creek
12	4	118	223	Lower East Fork Duck Creek
13	3	20	202	Sandy Run
14	3	24	201	Dickason Run
15	1	170	200	Lower Conotton
16	3	74	199	Lower Moxahala
17	3	51	190	West Branch Sunday Creek
18	2	142	183	Middle Wheeling Creek
19	4	33	181	Upper Leading Creek
20	4	119	179	West Fork Duck Creek
21	3	3	174	Lower Pine Creek
22	1	164	170	Lower Middle Tuscarawas
23	2	156	165	Boggs Fork
24	2	141	153	Lower Wheeling Creek
25	1	173	150	Middle Tuscarawas River
26	2	148	148	Lower Short Creek
27	2	143	147	Upper Wheeling Creek
28	3	48	133	Lower Sunday Creek
29	2	194	128	Piedmont Lake
30	3	54	125	Upper Monday Creek
31	2	195	121	Skull Fork
32	2	193	118	Upper Stillwater
33	1	169	115	Oldtown Creek
34	1	53	113	Lower Monday Creek
35	3	50	113	Upper Sunday
36	4	9	113	Sand Fork
37	3	52	111	Snow Fork
38	3	18	107	Upper Little Raccoon
39	3	21	106	East & West Branches

TABLE 20 (Continued)

Overall Ranking By Planning Unit

Rank	Region	PU's	Total	Name
40	2	149	103	Middle Short Creek
41	4	108	96	Upper East Fork Duck Creek
42	2	151	94	North Fork
43	2	138	94	Lower McMahon Creek
44	2	150	89	Piney Fork
45	2	145	88	Deep Run
46	2	215	88	Lower Cross Creek
47	2	152	88	Upper Short Creek
48	1	175	87	Walnut Creek
49	3	16	87	Middle Raccoon Creek
50	2	144	82	Crabapple Creek
51	1	167	81	South Fork of Sugar Creek
52	3	17	79	Puncheon Fork
53	2	216	77	Upper Cross Creek
54	1	201	72	Upper Yellow Creek
55	1	81	70	Symmes Creek
56	1	166	69	Lower Tuscarawas
57	1	82	67	Upper Muskingum River
58	2	139	66	Middle McMahon Creek
59	2	203	64	Little Yellow Creek
60	4	132	64	Buffalo Creek
61	2	146	63	Little Short Creek
62	4	11	62	Upper Symmes Creek
63	1	128	61	Baron Creek
64	3	4	61	Upper Pine Creek
65	2	202	56	North Fork Yellow Creek
66	1	168	55	Stone Creek
67	1	127	55	Lower Wills Creek
68	1	126	55	White Eyes Creek
69	4	10	54	Black Creek
70	4	8	51	Middle Symmes Creek
71	2	137	48	Pipe Creek
72	2	199	48	Lower Yellow Creek
73	4	7	45	Lower Symmes Creek
74	1	165	43	Evans Lake
75	2	162	41	Lower Stillwater
76	1	172	37	Atwood Lake
77	2	200	36	Middle Yellow Creek
78	2	198	32	Town Fork

Regions 3 and 4 dominate the top twenty planning unit overall rankings. Extremely serious widespread problems of erosion, sedimentation, and water quality in regions 3 and 4 are reflected in the regional distribution of the top twenty matrix scores. It is interesting to note that 17 of the 25 completed orphan strip mine reclamation projects, documented during this study, are in regions 3 and 4. This indicates that the seriousness of the erosion, sedimentation, and water quality problems in regions 3 and 4 has been recognized by State and Federal agencies as well as by the affected public.

F. Cost Estimates

A study of reclamation cost for completed projects was undertaken by the ODNR, Division of Reclamation. Projects included those completed by the Division of Reclamation and by the U.S. Soil Conservation Service. Cost estimate statistics were generated for strip mine reclamation, gob pile reclamation, vertical shaft reclamation and horizontal entry reclamation. The study showed that strip mine reclamation costs could be broken down by geologic region. The following average 1985 costs were obtained in the study.

TABLE 21 - Reclamation Cost Per Unit

Reclamation Effort	Cost
Strip Mine Reclamation	
Region 1	$10,394/acre
Region 2	$10,981/acre
Region 3	$ 5,481/acre
Region 4	$ 6,602/acre
Gob Piles - All Regions	$13,567/acre
Vertical Shafts	$10,000/acre
Horizontal Entries	$21,400/acre

Cost estimates for strip mine reclamation seemed to be more dependent on contracting procedures, and on the acreage of the site, than on the actual site conditions themselves.

Cost estimates for other reclamation procedures were undertaken on a site by site basis using the following cost guidelines provided by the Ohio Division of Reclamation.

TABLE 22 - Reclamation Costs Per Unit

Reclamation Effort	Cost
Landslides	
Small site (1-2 acres)	$ 15,000
Medium site (5-10 acres)	$ 50,000
Large site (10-100 acres)	$250,000
Dangerous Mine Refuse Pile (non-burning)	$ 10,000/acre
Trash Dump (non-burning)	$ 6,000/acre
Abandoned Equipment	$ 10,000/structure
$ 2,500/piece	
Dangerous Highwall (associated strip mine reclamation is cost determinant)	$ 10,000/acre
Dangerous Impoundment	$ 10,000/acre
Mine Portal with Mine Discharge	
Installation of Mine Drain	$ 15,000/entry
Installation of Mine Seal	$ 25,000/entry
Polluted Impoundment Treatment	$ 5,000-10,000/pond (0.5-1 million gal)

Strip mine reclamation sites in regions 3 and 4 averaged from 70 to 90 acres in size ($5,481/acre and $6,602/acre). Sites in regions 1 and 2 averaged from 4.8 to 5 acres in size with average reclamation costs of $10,394/acre and $10,981/acre respectively. It appears that physically larger sites can be more efficiently reclaimed than the smaller ones, thus demanding a lower contract cost per acre. The smaller sites generally have a high percentage of their surface area in the steep out-slope position. The steeper slopes generally require a more intensive and costly reclamation effort than benches or other relatively flat spoil areas common to larger sites. The unpredictability of competitive bidding, utilized in state and Federal contracting, adds a degree of uncertainty to site specific cost estimates.

Chapter III - Opportunities for Implementation - Agencies

Ohio Department of Natural Resources, Division of Reclamation - The Division of Reclamation, ODNR, is the primary agency in the State of Ohio responsible for the restoration of abandoned mined land and the correction of mining-related problems. This Division, under a variety of names, has been enforcing strip mining laws and investigating mining problems in Ohio since 1948.

The Division derives its authority to deal with AML problems from Ohio House Bill 244 and the Federal Surface Mining Control and Reclamation Act, both passed in 1977. These state and federal laws impose severance taxes of $0.04 and $.35 respectively on the mining of each ton of coal in Ohio.

The Division of Reclamation receives the majority of these tax dollars to conduct AML reclamation in Ohio. Ten to fifteen million dollars is received by the Division annually for AML reclamation of which a portion is transferred to other state, local, or federal agencies under various cooperative programs. With its concurrent state and federally funded programs, the Division of Reclamation conducts reclamation projects to correct both public hazards and environmental problems.

U.S. Soil Conservation Service - The Soil Conservation Service (SCS) is a federal agency within the U.S. Department of Agriculture. It was established in 1935 to provide national leadership in the conservation and wise use of soil, water, and related resources through a balanced cooperative program that protects, restores, and improves those resources. Mined lands can be reclaimed under the Small Watersheds Program, Conservation Operations Program, Rural Abandoned Mine Program, and under the Resource Conservation and Development Program.

Office of Surface Mining - The Office of Surface Mining Reclamation and Enforcement (OSM) approves annual grant applications to States and Indian tribes under Title IV of the Surface Mining Control and Reclamation Act of 1977 for the reclamation of abandoned mine land. These funds come from revenues from reclamation fees levied on the coal industry. Collections by OSM are to continue through 1992. Of the total fees collected in the state or on Indian lands, 50 percent constitutes the State and Indian tribe share of the fund which is to be returned to the State or Indian tribe in the form of grants.

U.S. Forest Service - The U.S. Forest Service (FS) is divided into three principal branches: the National Forest System, State and Private Forestry, and Forest Research. All three of these are represented in the basin.

Under provisions of the Organic Administration Act of 1897 and PL 86-517, Congress established that the renewable surface resources of the National Forest (primarily outdoor recreation, forage, timber, water, and wildlife and fish habitat) shall be administered for multiple use and sustained yield. Within the framework of this legislation and dependent upon funds available, reforestation, timber stand improvement, forest fire, management, and a variety of other resource protection and management activities are implemented. In 1976, PL 85-233 reaffirmed the principles of multiple use and sustained yield. The new act provides directives for planning, guidelines for timber harvesting, provisions for public involvement, and other aspects of National Forest System management.

State and private forestry functions are conducted under PL 95-313. This arm of the Forest Service has responsibility for providing national leadership and technical and financial assistance to resource managers and operators of nonfederal forest lands.

On August 3, 1977, Public Law 95-87 was approved by the U.S. Congress and the President of the United States for the regulation of surface coal mining operations (Title V) and for the reclamation of abandoned mines (Title IV). Title IV of the law established an Abandoned Mine Land Reclamation Fund (AMLR Fund) and authorizes the Secretary of the Interior to administer the funds. With the enactment of this law, a reclamation fee of 35 cents per ton of surface mined coal and 15 cents per ton of underground mined coal was assessed on all active coal operations in the United States. These fees accumulate in the Abandoned Mined Lands Fund from which the Office of Surface Mining (OSM) distributes funds for specific reclamation projects. Fee collection began in 1978 and will extend through 1992.

Of the funds collected through the fee, fifty percent will return directly to the originating states for the purpose of conducting reclamation projects upon approval of the State's Abandoned Mined Lands Program by the OSM. Of the remaining fifty percent of funds, up to twenty percent will be made available to the Soil Conservation Service for the funding of the Rural Abandoned Mined Program, ten percent will be used in administering the Small Operators Assistance Program (S.O.A.P.), and twenty percent will be allocated at the discretion of the OSM among the contributing states.

<u>Soil Conservation Service Programs</u> - The Soil Conservation Service (SCS) has authority from several legislative actions. Under PL 74-46, the SCS has a broad program of soil and water conservation and development. Their principal function is to assist landowners and operators in the planning of land use and the installation of land treatment measures. Under PL 83-566, the SCS provides technical and financial assistance to state and local organizations for watershed protection, flood prevention, fish and wildlife enhancement, public recreation, irrigation, and drainage. Loan assistance is also available for constructing municipal and industrial water supply reservoirs. To date, four watershed projects have been completed, one is in the process of being installed, and one has been approved for installation.

Resource Conservation and Development (RC&D) projects authorized under PL 87-703 are to assist conservation districts and local government or individuals to improve economic, environmental, or social conditions in their communities in multi-county areas. For accelerated conservation or land use change activities, SCS can provide technical and financial assistance to eligible sponsors. The basin contains two active RC&D projects.

Title IV, of Public Law 95-87, established funds and programs for the reclamation of abandoned mines. SCS is responsible for the Rural Abandoned Mine Program. Under this program, SCS, through conservation districts, provides long-term federal technical and financial assistance to land users for the reclamation, conservation, and development of certain abandoned coal-mined lands. More specifically, the program's objectives are to (1) stabilize mined lands, (2) control erosion and sediment on mined areas and areas affected by mining, (3) reclaim lands and water for useful purposes, (4) enhance water quality or quantity where it has been disturbed by past coal mining practices, and (5) remove hazards to life and property caused by past mining.

In addition to these authorities, SCS provides information and data on soil, land use, and the magnitude of problems within a region. The SCS Soil Survey and Resource Inventory Programs have historical and current data available upon request from state and local offices.

U.S. Forest Service Programs - The Cooperative Forestry Assistance Program is authorized under Public Law 95-313 (92-Stat.-365), 1978. This Act authorizes the Secretary of Agriculture to assist non-Federal forestland owners in:

1. Advancement of forest resources management;

2. Encouragement of production of timber;

3. Prevention and control of insects and diseases affecting trees and forests;

4. Prevention and control of rural fires;

5. Efficient utilization of wood, including recycling;

6. Improvement and maintenance of fish and game habitat; and

7. Planning and conduct of urban forestry programs.

This Act also authorizes the Secretary to work through, and in cooperation with, the State Foresters or equivalent State officials in implementing the following Federal programs affecting non-Federal forestlands by providing financial, technical and other assistance in the areas listed.

Rural Forestry Assistance:

1. Plant tree seeds and trees for afforestation or reforestation on suitable land for timber and other benefits;

2. Plan, organize and implement measures on non-Federal forestlands to improve the multiple use management on these lands;

3. Protect or improve soil fertility on non-Federal forestlands and quality, quantity and timing of water yields; and

4. Provide technical information, advice, and related assistance in:

    a. Harvesting, processing and utilization of wood and wood products and other forest products;

    b. Conversion of wood to energy for domestic, industrial, municipal and other uses;

    c. Management planning and treatment of forestlands to improve quality of timber and other resources;

d. Protection and improvement of forest soil fertility and quality, quantity, and timing of water yields; and

e. Effects of forestry practice on fish and wildlife and their habitats.

Rural Fire Prevention and Control:

Besides the authority provided in the Federal Fire Prevention and Control Act of 1974, the Secretary is authorized to:

1. Cooperate with State Foresters in developing systems and methods for prevention, control, suppression and prescribed use of fires on rural communities to protect lives and values;

2. Provide financial, technical, and related assistance to protect these lands, and

3. Finance the organizing and timing of fire fighting forces.

Agricultural Conservation Program:

The Agricultural Conservation Program is administered by local offices of the Agricultural Stabilization and Conservation Service (ASCS). Through cost-sharing arrangements, landowners can solve resource conservation and pollution problems. Two of the Best Management Practice (BMP) that are available to forestland managers are a tree planting measure and a measure to establish permanent grass cover. Either or both can be used to resolve erosion problems on old fields, forestlands, and forest roads. The ASCS current cost-sharing rates pay from 50 to 65 percent of the total BMP cost.

Forestry Incentives Program:

The Forestry Incentives Program is administered by local offices of the Agricultural Stabilization and Conservation Service (ASCS). Through cost-sharing, private landowners are able to obtain up to 65 percent of the cost of planting trees on lands suitable for the production of timber products. This program also cost-shares on such measures as pre-commercial thinning, pruning of crop trees, site preparation for natural regeneration and releasing desirable seedlings and young trees.

Chapter IV - Alternative Plans

Introduction:

The objectives, National Economic Development (NED), and Environmental Quality (EQ), were used to formulate alternative plans for the Abandoned Mined Lands Study. Two alternative plans were evaluated: the "no action" alternative emphasizing the NED objective, and Alternative Plan 2, emphasizing EQ concerns. Measures included in Alternative Plan 2 were selected based on their effectiveness in reducing or eliminating the problems associated with abandoned mined lands.

A. National Economic Development Plan

The NED Plan for the Abandoned Mined Land Study is the "no action" alternative. The average cost per acre for reclamation ranges from $5,500 per acre to $11,000 per acre, depending on the nature of the work required to solve the problem. This cost far exceeds the economic benefits that would result from the installation of these measures.

On the site itself, reclamation usually results in the eventual establishment of grass. This land, however, is too fragile to support grazing by livestock. There are, therefore, no measureable on-site economic benefits. Benefits from reclamation work are limited to the downstream impact areas. These benefits are in the form of reduced channel, road, ditch, and culvert maintenance. This is the result of greatly decreased sedimentation and reduced flooding in the future due to maintenance of existing channel capacity.

Flooding attributable to past mining activity in downstream impact areas does relatively minor damage. Much of the cropland in the flood plains has been abandoned or converted to pasture. The abandoned cropland is either barren, has reverted to woody vegetation, or is in some cases, wetland vegetation. Most of the flood damage occurs to roads and residential or commercial properties, with some damage to utilities. Flood damages from the 100-year flood event which are attributable to strip mining are summarized by region in the following table:

TABLE 23

100-Year Flood Damages

Related to Abandoned Strip Mines (Dollars)[1/]

Region	Residential Properties	Public & Commercial Properties	Bridge Damage	Other Transportation & Utilities	Total
1	-	-	100	100	200
2	18,200	-	2,900	200	21,300
3	63,400	3,200	48,300	41,400	156,300
4	154,600	8,300	83,600	199,900	446,400
Total	236,200	11,500	134,900	241,600	624,200

1/ Price Base: 1985

It should be noted that these damages reflect flooding only in the downstream impact areas and only due to past mining activities.

Flood damages vary considerably by region, both in the total amount and the type of property that is damaged. This is due to the nature of the development on the flood plain within the problem areas. In addition, there is a large variation in the amount of sediment deposition that occurs in stream channels between the regions.

Costs to reclaim a typical site in each region are shown in the following table:

TABLE 24

Reclamation Cost of a Typical Site

	Region 1		Region 2		Region 3		Region 4	
	Number of Sites	Cost 1/	Number of Sites	Cost 1/	Number of Sites	Cost 1/	Number of Sites	Cost 1/
Resoil and Reseed Barren Land	17	$1,032	18	$687	18	$1,957	18	$7,638
Channel Sediment Removal	3	117	4	88	3	193	10	335
Remove Abandoned Equipment	2	10	2	10	1	20	-	-
Backfill Dangerous Impoundments	1	10	-	-	2	30	-	-
Remove Dangerous Highwall	3	10	2	20	1	30	-	-
Acid Mine Drainage	2	40	-	-	2	40	-	-
Stabilize Dangerous Highwall	1	50	6	23	-	-	-	-
Close Dangerous Mine Openings	-	-	6	14	10	18.3	-	-
Stabilize Dangerous Pile	-	-	2	50	1	500	-	-

1/ Average cost per site, in thousands.

B. Environmental Quality Plan

The Environmental Quality (EQ) Plan consists of treating all identified problems associated with abandoned mine lands.1/ Measures included in this plan are revegetation of barren lands, removal of sediment clogging streams near bridges and culverts, backfilling dangerous impoundments, removal of dangerous highwalls, sealing sources of acid mine water, sealing dangerous mine shafts, and other measures.

Basin-wide 20,180 acres of barren, strip-mined land will be revegetated. This will reduce total erosion by 3,744,190 tons per year. Sedimentation will be reduced by a proportional amount. Approximately 231,500 tons of sediment would be removed from stream channels near bridges and culverts. Six dangerous highwalls would be removed. Four identified sources of acid mine drainage would be sealed. Dangerous landslides endangering safety would be stabilized at nine sites. Sixteen dangerous mine shafts would be closed.

The plan elements and costs are summarized by region in Table 25:

1/ Appendix 8 presents a detailed breakdown by watershed and planning unit of all identified problems, needs, costs, and effects utilized in the Environmental Quality Plan.

TABLE 25

Plan Elements and Effects

Item	Region 1	Region 2	Region 3	Region 4	Basin Total
Resoil and Reseed Barren Lands					
Acres	1,690	1,110	6,420	10,960	20,180
Costs1/	17,550	12,359	35,219	72,347	137,475
Channel Sediment Removal					
Tons	17,500	17,500	29,000	167,500	231,500
Costs1/	350	350	580	3,350	4,630
Remove Abandoned Equipment					
Sites	2	2	1	-	5
Costs1/	20	20	20	-	60
Backfill Dangerous Impoundments					
Sites	1	-	2	-	3
Costs1/	10	-	60	-	70
Remove Dangerous Highwall					
Sites	3	2	1	-	6
Costs1/	40	40	30	-	110
Seal Dangerous Landslides					
Sites	2	-	2	-	4
Costs1/	40	-	80	-	120
Stabilize Dangerous Landslides					
Sites	2	7	-	-	9
Costs1/	100	140	-	-	240

TABLE 25 (Continued)

Plan Elements and Effects

Item	Region 1	Region 2	Region 3	Region 4	Basin Total
Seal Dangerous Mine Shafts					
Sites	-	6	10	-	16
Costs1/	-	80	180	-	270
Resoil and Reseed Dangerous Gob Piles					
Sites	-	2	1	-	3
Costs1/	-	100	500	-	600
Other Measures					
Sites	-	-	32/	-	3
Costs1/	-	-	120	-	120
Total Costs	18,106	13,092	36,793	75,698	143,699

1/ All costs are in thousands of dollars.
2/ Includes removal of one tipple (10,000), treatment of polluted lake water (10,000), and one sediment dam (100,000).

There are two sources of funding for reclamation of abandoned mines in Ohio. The Ohio Department of Natural Resources, Division of Reclamation, and the Rural Abandoned Mine Program (RAMP) administered by the Soil Conservation Service.

The ODNR, Division of Reclamation program has an annual budget of $20 million. Of this total, approximately $15 million is for construction. Approximately $13 million comes from Federal funds, an additional $3 million comes from the state severance tax on coal (currently 4-5 cents per ton), and an additional $3-4 million comes from bond forfeitures.

RAMP has an annual budget allocated to Ohio of approximately $800 thousand for financial assistance and $300 thousand for technical assistance. Therefore, the total annual funds available for reclamation are about $16.1 million. At this level of funding, the EQ Plan could be completed by 1994. However, Federal funding expires in 1992. With only state funds available after 1992, it will take an additional ten years to implement the EQ Plan.

Implementing the EQ Plan will not solve all problems associated with abandoned mines. Water quality problems due to acid mine drainage from deep mines will remain. Lands in downstream impact areas which were swamped by strip mine sediment will remain in that condition for long periods of time. Many stream reaches clogged with sediment will be left to naturally degrade over time. Former agricultural lands that have had infertile sediments deposited on them will remain in their present condition.

Continuation of Federal funding at current levels through 1994 would allow for more timely completion of the elements in this plan. The Division of Reclamation could devote more funds to research after 1994. This could result in new, more effective reclamation technologies in the future.

APPENDIX 1

Physical Characteristics

The State's coal field lies on the northwestern edge of a large geologic structure called the Main Bituminous Coal Basin. This basin extends from North-central Pennsylvania through Eastern Ohio, West Virginia and Western Maryland and southward into Alabama. Coal-bearing deposits underlie roughly the eastern third, or 11,000 square miles, of the State. The coal field occurs in a northeast-southwest oriented, 180-mile-long band along the Ohio River, which averages 60 miles in width. Coal mined lands are found within four major river basins: The Scioto, Muskingum, Beaver and Hocking Rivers. All of the coal mined lands are within the Ohio River Basin. This vast study area included all or portions of the 26 eastern counties listed below.

Athens	Holmes	Noble
Belmont	Jackson	Perry
Carroll	Jefferson	Portage
Columbiana	Lawrence	Stark
Coshocton	Mahoning	Tuscarawas
Gallia	Meigs	Vinton
Guernsey	Monroe	Washington
Harrison	Morgan	Wayne
Hocking	Muskingum	

APPENDIX 2

Climate

The climate of the area may be roughly characterized as "continental" in that the seasonal temperature range is moderately wide and precipitation is distributed in a typical pattern. Being located west of the Appalachians weather changes are brought on by storms which have already traversed much of the United States. Heat and moisture are brought northward from the Gulf and the Carribbean, while outbreaks of cold polar air can easily penetrate this far south. As a result summers are warm and humid and the winters are mildly cold with zero or below temperature readings occurring on the average 3 or 4 times per year. The average annual temperature varies from 50°F in the northern counties to about 55°F in the southern counties. The average annual precipitation varies from 35 to 42 inches. The growing season varies from approximately 150 days in the northern portion to 180 days in the southern portion.

APPENDIX 3

Land Resources

The proposed study area consists of 26 coal-bearing counties in eastern Ohio bounded on the east by the Ohio River and a portion of the Pennsylvania State Line and on the west by a line from Cleveland to Portsmouth. The 26 county area contains 30 watersheds identified by the Ohio Division of Reclamation as having priority over all others for their reclamation efforts. The area is in the Appalachian Plateau and is the most scenic portion of the state. It is underlain primarily by Pennsylvania Age sandstones, shales, limestones, and coal which have a regional dip of about 30 feet per mile to the southeast.

Mineral resources are abundant in the area. Coal is by far the most valuable with 12 mineable coal seams of regional extent. Less than half of these seams have been mined to any degree. Other mineral resources include oil, gas and fire clay, shale, limestone, sand, and gravel.

Soils are predominantly formed from the weathering of local bedrock. Soils formed from glacial till occur in the northernmost counties.

The total land area in the 26 counties is 12,453 square miles and, according to the 1970 census, has a population of about 1.75 million of which over 40 percent is urban. The principal cities are Athens, Canton, Marietta, Steubenville, Youngstown, and Zanesville. About 3.2 million acres are in farms with nearly 30 percent in crops and 17 percent in pasture. The balance of the farmland is in woods and idle land. Portions of the Wayne National Forest are located in eight of the counties in the study area and totals 173,000 acres. The majority of approximately 20,000 farms in the area average between 150 and 200 acres.

APPENDIX 4

Water Quantity, and Quality

Surface water resources include both streamflows and natural or artificial surface impoundment reservoirs. The surface water quantity is sustained wholly by precipitation either from direct surface runoff or indirectly from percolation through the earth's crust into underground water reservoirs which, in turn, overflow into the stream.

There is a natural range in dissolved and suspended solids in surface water which results largely from the manner and time it takes the water to reach the streams. When rain or melted snow reaches the stream quickly over the surface of the ground, the quantity of dissolved solids is generally small and the quantity of suspended solids relatively large. Surface water can generally be expected to have higher suspended solids and lower dissolved solids in March and April, and lower suspended solids and higher dissolved solids in August and September.

As compared to underground water, surface water is turbid and likely to be contaminated, but is generally lower in dissolved solids and hardness. Underground water is one of the most important natural resources of southeast Ohio. Approximately 85 percent, or 154 out of 181 public water supply systems in existence in 1975, obtained their supply from wells. In addition, approximately four percent, or seven systems, had a combined source of supply from both underground and surface. The 1975 average daily water usage from underground water supply sources for public systems relying totally or partially on aquifers was approximately 92 million gallons out of a total of 140 million gallons. Private industrial and rural use accounts for additional underground water withdrawals.

The quality of underground water is governed primarily by the concentrations of dissolved substance derived from soluble minerals in the surrounding material. Underground waters in most instances, in properly developed wells, are virtually free of suspended matter and harmful microorganisms. Underground water quality is usually suitable as a source of supply for a public system with conventional treatment. Usual treatment consists of disinfection, iron and manganese removal, occasionally softening and flouridation.

There are 31 recreational facilities (7,500 acres) in the high-priority drainage basins. These include national and state forests, parks, wildlife areas, and historical sites. Twenty-one of which provide water-related recreational opportunities. In general, populated areas lack adequate recreational facilities. Consequently, water facilities and flood plains provide highly desirable recreation sites in urban areas.

APPENDIX 5

Number of Households by Income Group 1/

County	Less Than $5,000	$5,000 - $7,499	$7,500 - $9,999	$10,000 - $14,999	$15,000 - $19,999	$20,000 - $24,999	$25,000 - $34,999	$35,000 - $44,999	$50,000 or More	Total
Athens	3,604	2,418	1,813	3,363	2,498	1,756	1,884	787	260	18,383
Belmont	4,213	2,725	2,306	4,307	4,726	4,274	5,211	1,936	620	30,318
Carroll	1,097	682	596	1,501	1,409	1,312	1,302	500	162	8,561
Columbiana	5,205	3,226	3,126	6,228	6,150	5,895	7,037	2,412	844	40,123
Coshocton	1,622	1,309	1,129	2,104	1,990	1,741	2,065	803	289	13,052
Gallia	1,731	951	879	1,760	1,424	1,289	1,484	543	240	10,301
Guernsey	2,360	1,402	1,424	2,691	2,308	1,954	1,940	712	252	15,043
Harrison	888	564	588	1,021	1,023	737	997	347	98	6,263
Hocking	1,294	779	807	1,632	1,495	1,130	1,020	341	96	8,594
Holmes	1,070	756	665	1,588	1,220	1,069	1,116	455	212	8,151
Jackson	2,168	1,180	976	1,833	1,682	1,184	1,121	373	164	10,681
Jefferson	4,380	2,581	2,394	4,250	4,264	4,358	6,609	2,865	1,012	32,713
Lawrence	3,819	2,072	1,873	3,305	3,338	3,088	3,113	1,152	345	22,105
Mahoning	14,435	7,469	7,474	14,107	15,129	15,094	17,500	8,117	3,267	102,592
Meigs	1,628	931	840	1,339	1,332	1,012	945	281	113	8,421
Monroe	999	558	460	864	760	881	1,063	311	99	5,995
Morgan	814	551	466	837	837	585	557	195	74	4,916
Muskingum	4,290	2,935	2,625	5,083	4,457	3,696	4,041	1,631	576	29,334
Noble	643	378	414	619	640	512	542	184	51	3,983
Perry	1,524	1,106	891	2,125	1,683	1,365	1,262	467	123	10,546
Portage	4,550	2,615	3,092	6,317	7,267	6,827	8,119	4,015	1,519	44,321
Stark	14,606	9,365	9,664	18,511	20,302	20,349	25,507	11,484	4,248	134,036
Tuscarawas	3,769	2,728	2,464	5,187	5,036	4,547	4,553	1,632	600	30,516
Vinton	777	489	395	709	590	424	371	114	44	3,913
Washington	2,867	1,794	1,728	3,814	3,845	3,014	3,526	1,196	513	22,297
Wayne	3,076	2,107	2,262	5,284	5,488	4,686	5,777	2,485	1,016	32,181
Total	96,226	59,548	56,431	110,301	109,876	100,864	118,065	49,145	18,372	718,828

Source: 1980 Census of Population and Housing, U.S. Department of Commerce, Bureau of the Census.
1/ Income in 1979.

APPENDIX 6

Use of the Resource Base

Past mining activities have had a profound impact upon individual landowners. Within the areas affected by mining, over 85 percent of what was once cropland is no longer being used for crop production. Over 70 percent of what was once grassland used for livestock is no longer used for this purpose. Table 6A shows average farm size and land use, and number of farms by county for the study area in comparison with all of Ohio in 1982.

For the study area as a whole, the impact of mining on agriculture has been slight. The cropland taken out of production in the problem areas is less than one percent of the total cropland in 1982. Grassland that has been idled or in another land use represents less than four percent of all pastureland in the 26 counties. Table 6B shows total acreages of land in farms by county in the study area, and the State of Ohio.

Mining has had little impact on water use. One lake in the study area has been identified as being polluted by acid mine drainage. Certain uses of this lake have therefore been impacted to some degree. Overall, however, mining has not affected water use to a large extent.

The impacts of mining on agricultural production parallel the effects on agricutural land use. Individual landowners have been affected, but output for the basin taken as a whole is increasing. This follows the general trend of increasing yields per acre for both Ohio and the United States.

TABLE 6A

Agricultural Land Use

County	Number of Farms	Average Size (Acres)	Cropland per Farm (Acres)	Woodland per Farm (Acres)	Pasture per Farm (Acres)	Other per Farm (Acres)
Athens	598	174	69	59	36	10
Belmont	743	182	82	46	36	18
Carroll	779	163	97	37	18	11
Columbiana	1,170	131	89	20	9	13
Coshocton	944	204	114	45	30	15
Gallia	992	128	57	41	19	11
Guernsey	937	157	74	39	31	13
Harrison	501	237	86	60	78	13
Hocking	411	146	67	54	14	11
Holmes	1,574	124	80	24	11	9
Jackson	503	161	88	41	17	15
Jefferson	514	148	71	44	20	13
Lawrence	630	122	42	49	23	8
Mahoning	766	114	80	16	8	10
Meigs	595	170	68	57	32	14
Monroe	825	158	67	54	28	9
Morgan	645	181	71	58	40	12
Muskingum	1,135	185	98	39	34	14
Noble	610	193	80	47	54	12
Perry	676	150	94	29	17	10
Portage	940	120	84	21	5	11
Stark	1,375	117	90	11	5	11
Tuscarawas	1,090	149	88	31	17	13
Vinton	249	203	68	85	19	32
Washington	1,088	146	65	47	24	10
Wayne	1,866	144	115	14	6	9
Study Area	22,156	152	83	36	21	12
State of Ohio	86,934	177	136	21	9	11

Source: 1982 Census of Agriculture.

TABLE 6B

Agricultural Land Use

County	Total Cropland (Acres)	Total Woodland (Acres)	Total Pasture (Acres)	Total Other (Acres)	Total Farmland (Acres)
Athens	41,099	35,580	21,375	5,706	103,760
Belmont	60,980	33,997	26,784	13,118	134,879
Carroll	75,917	28,631	13,807	8,492	126,847
Columbiana	104,268	23,395	10,810	14,778	153,251
Coshocton	107,559	42,363	28,376	14,435	192,733
Gallia	56,191	40,994	18,699	10,631	126,515
Guernsey	69,211	36,779	29,430	11,949	147,369
Harrison	43,108	29,817	39,258	6,386	118,569
Hocking	27,426	22,373	5,688	4,542	60,029
Holmes	126,425	37,118	17,516	13,904	194,963
Jackson	44,304	20,451	8,323	7,885	80,963
Jefferson	36,746	22,391	10,035	7,123	76,295
Lawrence	26,327	30,609	14,331	5,397	76,664
Mahoning	61,549	12,228	5,778	7,427	86,982
Meigs	40,181	33,867	18,870	8,440	101,358
Monroe	55,370	44,317	23,387	7,468	130,542
Morgan	45,475	37,496	26,097	7,427	116,495
Muskingum	110,947	44,402	38,489	15,995	209,833
Noble	48,965	28,909	32,797	7,207	117,878
Perry	63,790	19,489	11,381	6,853	101,513
Portage	78,643	19,677	4,765	10,003	113,088
Stark	123,250	15,485	6,817	15,068	160,620
Tuscarawas	95,773	33,800	18,410	14,474	162,457
Vinton	16,895	21,071	4,656	7,892	50,514
Washington	70,531	51,592	26,124	11,142	159,389
Wayne	213,671	26,815	11,178	16,770	268,434
Study Area	1,844,601	793,646	473,181	260,512	3,371,940
State of Ohio	11,824,451	1,860,945	779,449	919,209	15,404,054

Source: 1982 Census of Agriculture.

APPENDIX 7

Fish and Wildlife

Wildlife is the major use of unreclaimed mined land in Ohio, but the quality of the habitat varies greatly due to the type and density of vegetative cover. Many limiting factors affect the vegetative community. Among the most harmful are soil acidity, toxic metals, erosion and resulting sedimentation, soil droughtiness, and the lack of essential plant nutrients.

Besides providing low quality cover, the mined land affects other aspects of the surrounding ecosystem. Highwalls interrupt travel lanes and lower water tables. Water quality is degraded by sedimentation, acidity, and toxic metals. Wetlands are also destroyed or degraded by sedimentation, acidity, and toxic materials. This can occur on-site or far downstream. Wetlands created by mining are usually of little or no value.

Most fisheries in the drainage area are severely limited because of poor water quality. The effects can be seen far downstream from the mined areas. Some created strip mine pits, however, can produce viable fisheries if the pH is greater than 6 and the lake is large and deep enough.

Threatened and endangered species may be present in the mined areas but because of the size of the study area and lack of existing data, no detailed analysis was conducted. If any of the areas were reclaimed, a site by site consideration would be needed. Reclamation of any or all of the sites should improve wildlife and fisheries habitat by decreasing the limiting factors and improving vegetative cover and water quality. There will usually be short-term impacts during construction due to increased erosion and sedimentation, existing habitat destruction, and species dispersal from the site. In most cases, habitat will be greatly improved after reclamation.

Archaeological and Historical Resources

Archaeological and historical resources probably existed in the impacted areas before mining, but it is doubtful that significant resources could still exist. The extensive earth moving would have destroyed many such sites. Because of the size of the study area, no detailed analysis was conducted. Archaelogic and historic resources may exist in potential borrow areas for resoiling operations. A site by site assessment must be conducted if any reclamation is planned.

Esthetics

Esthetics of mined land leaves much to be desired. Many areas are completely void of vegetation, have huge gullies, and orange water, to mention a few. Other areas look well vegetated from a distance but lack needed understory. Many areas are used as trash dumps or for junked vehicles. The visual quality of reclaimed areas can be temporarily impaired during construction. Existing vegetation will be lost, the topography will be changed, air pollution from dust and exhaust emissions will increase due to construction operations, and sedimentation may be increased. After construction, the visual quality should be greatly increased due to elimination of many of the unsightly landscape features and applied conservation practices to improve vegetative cover and diversity.

APPENDIX B

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
1	12	Leading Creek	32	10	Severe erosion, 1,400 acres	Resoiling - Prep. & Seeding	9,243	Saved 71,235 tons/yr.
					Clogged Stream	Sediment Removal	200	Reduction in flooding
						Sub-total	9,443	
			33	19	Severe erosion, 279 acres	Resoiling - Prep. & Seeding	1,841	Saved 14,355 tons/yr.
					Clogged Stream	Sediment Removal	50	Reduction in flooding
						Sub-total	1,891	
			34	9	Severe erosion, 1,455 acres	Resoiling - Prep. & Seeding	9,606	Saved 30,360 tons/yr.
					Clogged Stream	Sediment Removal	50	Reduction in flooding
						Sub-total	9,656	
						Total	20,990	
2	55	Wheeling Creek	141	24	Severe erosion, 54 acres	Resoiling - Prep. & Seeding	592	Saved 761 tons/yr.
					Landslides - 3	Resoiling - Prep. & Seeding	45	Safer environment
					Dangerous Pile - 1	Resoiling - Prep. & Seeding	50	Safer environment
						Sub-total	687	
			142	18	Severe erosion, 89 acres	Resoiling - Prep. & Seeding	977	Saved 1,164 tons/yr.
					Garbage & trash dump	Resoiling - Prep. & Seeding	6	Safer environment
					Abandoned Equipment	Removal	10	Safer environment
					Dangerous Pile - 1	Resoiling	50	Safer environment
						Sub-total	1,043	
			143	27	Severe erosion, 1 acre	Resoiling - Prep. & Seeding	11	Stabilize 1 acre
					Dangerous Highwall	Removal	20	Safer environment
					Landslide	Stabilization	15	Safer environment
						Sub-total	46	
			144	30	No problems identified		0	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
2	55	Wheeling Creek	145	45	Severe erosion, 24 acres	Resoiling - Prep. & Seeding	494	Saved 268 tons/yr.
					Portals - 4	Sealing	63	Safer environment
					Landslide - 1	Stabilization	15	Safer environment
					Abandoned Equipment	Removal	10	Safer environment
						Sub-total	687	
						Total	2,358	
3	56	Short Creek	146	61	Severe erosion, 50 acres	Resoiling - Prep. & Seeding	549	Saved 716 tons/yr.
						Sub-total	549	
			148	26	Severe erosion, 30 acres	Resoiling - Prep. & Seeding	329	Saved 900 tons/yr.
					Clogged Stream	Sediment Removal	50	Reduction in flooding
					Landslide	Stabilization	15	Safer environment
						Sub-total	394	
			149	40	Severe erosion, 225 acres	Resoiling - Prep. & Seeding	2,470	Saved 3,410 tons/yr.
					Clogged Stream	Sediment Removal	50	Reduction in flooding
						Sub-total	2,520	
			150	44	Severe erosion, 14 acres	Resoiling - Prep. & Seeding	154	Saved 210 tons/yr.
					Clogged Stream	Sediment Removal	50	Reduction in flooding
						Sub-total	204	
			151	42	Severe erosion, 28 acres	Resoiling - Prep. & Seeding	307	Saved 466 tons/yr.
						Sub-total	307	
			152	47	Severe erosion, 118 acres	Resoiling - Prep. & Seeding	1,296	Saved 1,790 tons/yr.
						Sub-total	1,296	
						Total	5,270	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
4	33	East & Middle Forks Duck Creek	107	4	Severe erosion, 1,535 acres	Resoiling - Prep. & Seeding	10,134	Saved 155,565 tons/yr.
					Clogged Stream	Sediment Removal	700	Reduction in flooding
						Sub-total	17,134	
			108	41	Severe erosion, 50 acres	Resoiling - Prep. & Seeding	330	Saved 2,940 tons/yr.
						Sub-total	330	
			118	12	Severe erosion, 810 acres	Resoiling - Prep. & Seeding	5,348	Saved 79,650 tons/yr.
					Clogged Stream	Sediment Removal	100	Reduction in flooding
						Sub-total	5,448	
						Total	22,912	
5	10	Little Raccoon	018	38	Severe erosion, 43 acres	Resoiling - Prep. & Seeding	236	Saved 2,586 tons/yr.
					Open Mine Shaft	Sealing	21	Safer environment
						Sub-total	257	
			024	14	Severe erosion, 448 acres	Resoiling - Prep. & Seeding	2,455	Saved 31,700 tons/yr.
					Open Portals - 2	Sealing	31	Safer environment
						Sub-total	2,486	
			025	5	Severe erosion, 805 acres	Resoiling - Prep. & Seeding	4,412	Saved 124,200 tons/yr.
					Open Mine Shafts - 2	Sealing	31	Safer environment
					Garbage Dump	Resoiling	18	Safer environment
					Clogged Stream	Sediment Removal	80	Reduction in flooding
						Sub-total	4,541	
						Total	7,284	
6	7	Ohio River Tribs.	043	6	Severe erosion, 769 acres	Resoiling - Prep. & Seeding	5,077	Saved 48,105 tons/yr.
					Clogged Stream	Sediment Removal	300	Reduction in flooding
						Sub-total	5,377	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
6	7	Ohio River Tribs.	044	1	Severe erosion 1,818 acres	Resoiling - Prep. & Seeding	12,002	Saved 134,700 tons/yr.
					Clogged Stream	Sediment Removal	700	Reduction in flooding
						Sub-total	12,702	
						Total	18,079	
7	49	Upper Stillwater	156	23	Severe erosion, 22 acres	Resoiling - Prep. & Seeding	241	Saved 8,600 tons/yr.
					Clogged Stream	Sediment Removal	200	Reduction in flooding
					Landslide		50	Safer environment
						Sub-total	491	
			193	32	No problems identified		0	
			194	29	No problems identified		0	
			195	31	No problems identified		0	
						Total	491	
8	29	Moxahala Creek	73	2	Severe erosion, 1,637 acres	Resoiling - Prep. & Seeding	8,972	Saved 2,525,585 tons/yr.
					Clogged Stream	Sediment Removal	200	Reduction in flooding
					Dangerous Highwall	Removal	30	Eliminate Safety Hazard
						Sub-total	9,202	
			74	16	Severe erosion, 68 acres	Resoiling - Prep. & Seeding	372	Saved 11,360 tons/yr.
					Dangerous Impoundment	Backfill	30	Eliminate Safety Hazard
					Dangerous Tipple	Removal	10	Eliminate Safety Hazard
						Sub-total	412	
						Total	9,614	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
9	21	Sunday Creek	048	28	Severe erosion, 120 acres	Resoiling - Prep. & Seeding	658	Saved 5,840 tons/yr.
					Dangerous Impoundment	Backfill	30	Eliminate Safety Hazard
					Abandoned Equipment	Removal	20	Eliminate Safety Hazard
					Shaft	Sealing	10	Eliminate Safety Hazard
						Sub-total	718	
			050	35	Severe erosion, 46 acres	Resoiling - Prep. & Seeding	252	Saved 3,510 tons/yr.
						Sub-total	252	
			051	17	Severe erosion, 32 acres	Resoiling - Prep. & Seeding	175	Saved 12,555 tons/yr.
					2 Portals - Mine Drainage	Sealing	80	Reduce Acid Pollution
						Sub-total	255	
						Total	1,225	
10	25	W. Fork Duck Creek	114	7	Severe erosion, 348 acres	Resoiling - Prep. & Seeding	2,297	Saved 53,505 tons/yr.
					Clogged Stream	Sediment Removal	250	Reduction in flooding
						Sub-total	2,547	
			119	20	Severe erosion, 414 acres	Resoiling - Prep. & Seeding	2,733	Saved 15,520 tons/yr.
					Clogged Stream	Sediment Removal	200	Reduction in flooding
						Sub-total	2,933	
						Total	5,480	
11	20	Monday Creek	052	37	Severe erosion, 85 acres	Resoiling - Prep. & Seeding	466	Saved 1,442 tons/yr.
					Dangerous Portal	Sealing	21	Eliminate Safety Hazard
						Sub-total	487	
			053	34	Severe erosion, 48 acres	Resoiling - Prep. & Seeding	263	Saved 967 tons/yr.
					Gasses from Deep Burning			
						Sub-total	263	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
11	20	Monday Creek	054	30	Severe erosion, 204 acres	Resoiling - Prep. & Seeding	1,118	Saved 2,771 tons/yr.
						Sub-total	1,118	
						Total	1,868	
12	2	Symmes Creek	007	73	Barren, 20 acres	Resoiling - Prep. & Seeding	132	Saved 400 tons/yr.
						Sub-total	132	
			008	70	Barren, 38 acres	Resoiling - Prep. & Seeding	250	Saved 572 tons/yr.
						Sub-total	250	
			009	36	Barren, 439 acres	Resoiling - Prep. & Seeding	2,898	Saved 5,516 tons/yr.
						Sub-total	2,898	
			010	69	Barren, 96 acres	Resoiling - Prep. & Seeding	633	Saved 1,304 tons/yr.
						Sub-total	633	
			011	62	Barren, 60 acres	Resoiling - Prep. & Seeding	396	Saved 1,080 tons/yr.
						Sub-total	396	
						Total	4,309	
13	59	Stone Creek	168	66	Severe erosion, 2 acres	Resoiling - Prep. & Seeding	21	Saved 30 tons/yr.
						Sub-total	21	
			169	33	Severe erosion, 110 acres	Resoiling - Prep. & Seeding	1,143	Saved 1,704 tons/yr.
					Abandoned Equipment	Removal	10	Eliminate Safety Hazard
					Dangerous Impoundment	Backfill	10	Eliminate Safety Hazard
					Clogged Stream	Sediment Removal	100	Reduction in flooding
						Sub-total	1,263	

APPENDIX B

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
13	59	Stone Creek	173	25	Severe erosion, 518 acres	Resoiling - Prep. & Seeding	5,384	Saved 7,550 tons/yr.
					Dangerous Highwalls - 2	Removal	20	Eliminate Safety Hazard
					Seeping Portal	Sealing	40	Improved Water Quality
					Clogged Stream	Sediment Removal	200	Reduction in flooding
						Sub-total	5,644	
						Total	6,928	
14	16	Raccoon Creek	020	13	Severe erosion, 149 acres	Resoiling - Prep. & Seeding	816	Saved 5,740 tons/yr.
						Sub-total	816	
			021	39	Severe erosion, 50 acres	Resoiling - Prep. & Seeding	274	Saved 1,122 tons/yr.
						Sub-total	274	
						Total	1,090	
15	14	Shade River	035	3	Severe erosion, 812 acres	Resoiling - Prep. & Seeding	5,361	Saved 50,310 tons/yr.
					Clogged Stream	Sediment Removal	800	Reduction in flooding
						Total	6,161	
16	53	Tuscarawas Trib.	164	22	Severe erosion, 206 acres	Resoiling - Prep. & Seeding	2,141	Saved 24,140 tons/yr.
					Dangerous Highwall	Removal	20	Eliminate Safety Hazard
					Clogged Stream	Sediment Removal	50	Reduction in flooding
						Sub-total	2,211	
			165	74	Severe erosion, 10 acres	Resoiling - Prep. & Seeding	10	Saved 120 tons/yr.
						Sub-total	10	
			166	56	Severe erosion, 53 acres	Resoiling - Prep. & Seeding	551	Saved 792 tons/yr.
						Sub-total	551	
						Total	2,772	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
17	28	Rush Creek	059	8	Severe erosion, 1,228 acres	Resoiling - Prep. & Seeding	6,785	Saved 183,735 tons/yr.
					Clogged Stream	Sediment Removal	300	Flood Reduction
					50 acres Gob Pile - Erosion	Resoil	500	Sediment Damage Reduction
					Sediment Delivery, 1,116 acres	Sediment Dam	100	Sediment Damage Reduction
						Total	7,685	
18	66	Yellow Creek	198	78	No problems identified		0	
			199	72	Dangerous Highwall - 1	Removal	20	Eliminate Hazard
						Sub-total	20	
			200	77	Severe erosion, 42 acres	Resoiling - Prep. & Seeding	461	Saved 822 tons/yr.
						Sub-total	461	
			201	54	Severe erosion, 47 acres	Resoiling - Prep. & Seeding	516	Saved 816 tons/yr.
						Sub-total	516	
			202	65	Severe erosion, 52 acres	Resoiling - Prep. & Seeding	571	Saved 789 tons/yr.
					Vertical Shaft - 1	Sealing	10	Eliminate Hazard
						Sub-total	571	
						Total	1,578	
19	64	Conotton Creek	170	15	Severe erosion, 399 acres	Resoiling - Prep. & Seeding	4,147	Saved 43,235 tons/yr.
					Abandoned Equipment	Remove	10	Eliminate Hazard
					Road Damaged by Seepage	Seal Horizontal Shaft	40	Eliminate Damage
						Sub-total	4,197	
			172	76	Severe erosion, 11 acres	Resoiling - Prep. & Seeding	114	Saved 150 tons/yr.
						Sub-total	114	
						Total	4,311	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
20	4	Pine Creek	003	21	Severe erosion, 1,342 acres	Resoiling - Prep. & Seeding	7,356	Saved 21,177 tons/yr.
					Polluted Lake Water	Treatment	10	Eliminate Hazard
						Sub-total	7,366	
			004	4	Severe erosion, 39 acres	Resoiling - Prep. & Seeding	214	Saved 585 tons/yr.
					Horizontal Portals - 3	Sealing	20	Eliminate Hazard
						Sub-total	278	
						Total	7,644	
21	5	Lower Raccoon	014	11	Severe erosion, 416 acres	Resoiling - Prep. & Seeding	2,746	Saved 20,500 tons/yr.
						Total	2,746	
22	50	McMahon Creek	137	71	Severe erosion, 52 acres	Resoiling - Prep. & Seeding	571	Saved 804 tons/yr.
						Sub-total	571	
			138	43	Severe erosion, 188 acres	Resoiling - Prep. & Seeding	2,064	Saved 2,870 tons/yr.
						Sub-total	2,064	
			139	58	Severe erosion, 39 acres	Resoiling - Prep. & Seeding	405	Saved 623 tons/yr.
						Sub-total	405	
						Total	3,040	
23	47	Lower Wills Creek	126	68	Severe erosion, 8 acres	Resoiling - Prep. & Seeding	83	Saved 120 tons/yr.
						Sub-total	83	
			127	67	Severe erosion, 38 acres	Resoiling - Prep. & Seeding	395	Saved 549 tons/yr.
					Dangerous Slide	Stabilization	50	Eliminate Hazard
						Sub-total	445	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
23	47	Lower Wills Creek	128	63	Severe erosion, 7 acres	Resoiling - Prep. & Seeding	73	Saved 110 tons/yr.
					Dangerous Slide	Stabilization	50	Eliminate Hazard
						Sub-total	123	
						Total	651	
24	58	Sugar Creek	167	51	Severe erosion, 10 acres	Resoiling - Prep. & Seeding	104	Saved 700 tons/yr.
						Sub-total	104	
			175	48	Severe erosion, 220 acres	Resoiling - Prep. & Seeding	2,287	Saved 14,000 tons/yr.
						Sub-total	2,287	
						Total	2,391	
25	11	Raccoon Creek & Elk Fork	016	49	Severe erosion, 46 acres	Resoiling - Prep. & Seeding	252	Saved 747 tons/yr.
						Sub-total	252	
			017	52	Severe erosion, 26 acres	Resoiling - Prep. & Seeding	143	Saved 430 tons/yr.
						Sub-total	143	
						Total	395	
26	61	Cross Creek	215	46	Severe erosion, 12 acres	Resoiling - Prep. & Seeding	132	Saved 201 tons/yr.
						Sub-total	132	
			216	53	Severe erosion, 50 acres	Resoiling - Prep. & Seeding	549	Saved 763 tons/yr.
						Sub-total	549	
						Total	681	

APPENDIX 8

Environmental Quality Plan - Reclamation by Planning Unit
Combined Ranking by Watershed

Watershed Matrix Rank Overall	Watershed	Watershed Name	PU	PU Rank	Problems	Needs	Cost X $1,000	Effects
27	41	Muskingum River Tributaries	081	55	Severe erosion, 27 acres	Resoiling - Prep. & Seeding	281	Saved 368 tons/yr.
						Sub-total	281	
			082	57	Severe erosion, 13 acres	Resoiling - Prep. & Seeding	135	Saved 190 tons/yr.
						Sub-total	135	
						Total	416	
28	68	Little Yellow Creek	203	59	Vertical Opening - 1	Sealing	10	Eliminate Hazard
						Total	10	
29	37	Buffalo Fork Wills Creek	132	60	Severe erosion, 200 acres	Resoiling - Prep. & Seeding	1,320	Saved 2,755 tons/yr.
						Total	1,320	
30	54	Stillwater Creek	162	75	Severe erosion, 32 acres	Resoiling - Prep. & Seeding	351	Saved 536 tons/yr.
						Total	351	

Appendix 9
Abandoned Mine Lands

Please locate on the attached map, all areas that you are personally aware of where abandoned mines are creating a problem. Circle and number each area on the map and describe the problem below by checking one or more of the items.

Please complete this questionnaire as soon as possible and return it with the map to your local SCS field office.

Area No. _____

Type of Problem

_____ Open mine shaft
_____ Hazardous Gasses
_____ Stream Channel filling
_____ Sediment deposition
_____ Highwall
_____ Subsidence
_____ Acid drainage
_____ Pile or embankment
_____ Surface or Underground burning
_____ Abandoned Equipment
_____ Other - Please Specify

Type of Hazard

_____ Possible loss of life
_____ Possible health hazard
_____ Loss of Cropland
_____ Loss of Wildlife Habitat
_____ Loss of Fish Habitat
_____ Increased Flooding
_____ Polluted Water
_____ Other - Please Specify

Comments

____

____

____

____

If additional information is needed, may we contact you? ____ yes ____ no.

Name ____
Address ____
Phone No. ____

☆U.S.Government Printing Office: 1985 — 647-091/21701